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EWLETT-PACKARD COMPANY / OPERATING AND SERVICE MANUAL

620A

SHF SIGNAL GENERATOR

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OPERATING AND SERVICING MANUAL

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MODEL 620A
SHF SIGNAL GENERATOR

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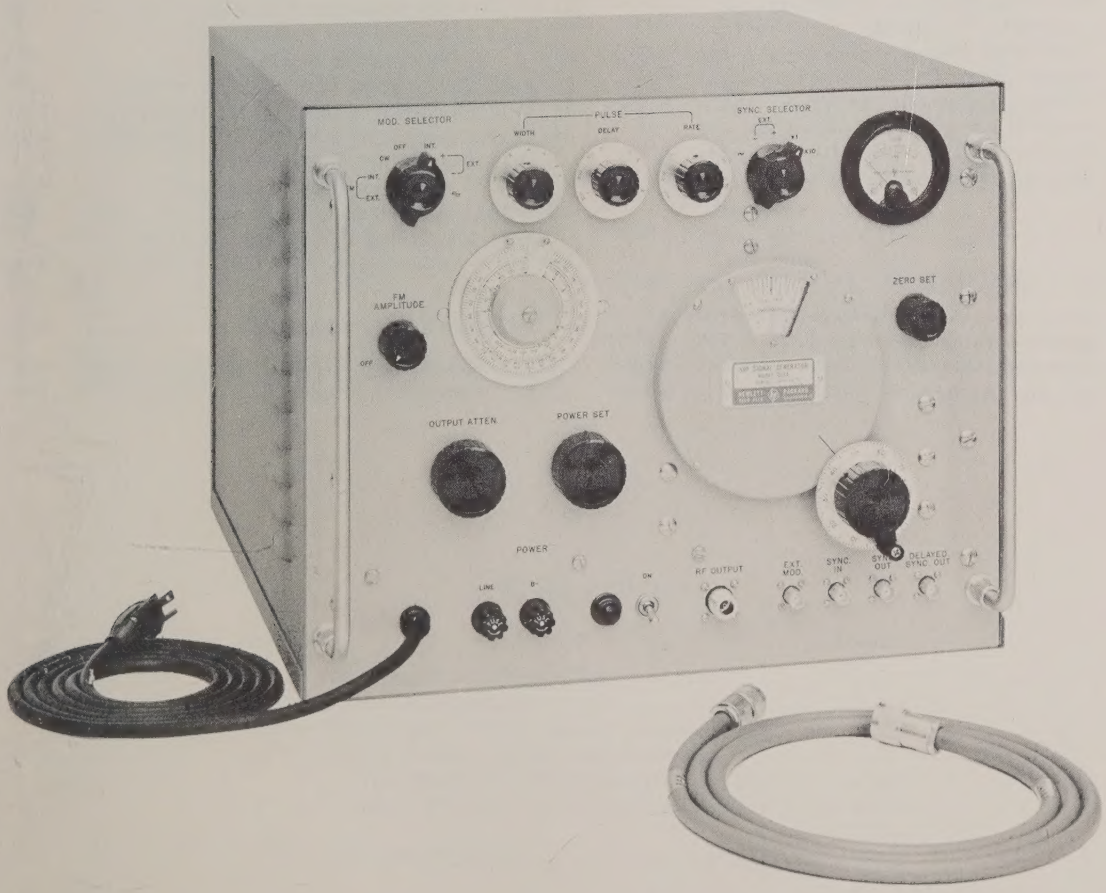

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SPECIFICATIONS

FREQUENCY RANGE:
7 to 11 gc covered in a single band. Repeller voltage automatically tracked and proper mode automatically selected.

CALIBRATION:
Direct reading. Frequency calibration accuracy better than 1%.

FREQUENCY STABILITY:
Frequency variation less than 0.006% /° C change in ambient temperature. Line voltage change of ±10 volts causes less than 0.02% frequency change.

OUTPUT RANGE:
1 milliwatt or 0.223 volt to 0.1 microvolt (0 dbm to -127 dbm) into 50 ohms. Directly calibrated in microvolts and db (coaxial type N connector).

OUTPUT ACCURACY:
Within ±2 db from -7 dbm to -127 dbm; within ±3 db from 0 dbm to -7 dbm, at panel connector, terminated in 50-ohm load.

INTERNAL IMPEDANCE:
50 ohms nominal (SWR less than 2).

MODULATION:
Internal or external pulse and fm; internal square wave.

INTERNAL PULSE MODULATION:
Repetition rate variable from 40 to 4000 pps, pulse width variable 1/2 to 10 microseconds.

SYNC OUT SIGNALS:
1) Simultaneous with rf pulse - positive.

2) In advance of rf pulse - positive, variable 3 to 300 microseconds. (Better than 1 microsecond rise time and 25 to 100 volts amplitude into 1000 ohm load.)

EXTERNAL SYNCHRONIZATION:
1) Sine wave: 40 to 4000 cps, amplitude 5 to 50 volts rms.

2) Pulse signals: Zero to 4000 pps and 5 to 50 volts amplitude, both positive and negative, pulse width 0.5 to 5 microseconds, rise time 0.1 to 1 microsecond.

INTERNAL SQUARE WAVE MODULATION:
Variable 40 to 4000 cps, controlled by "pulse rate" control.

INTERNAL FREQUENCY MODULATION:
Saw-tooth sweep rate adjustable between 40 to 4000 cps. Frequency deviation up to ±2.5 mc.

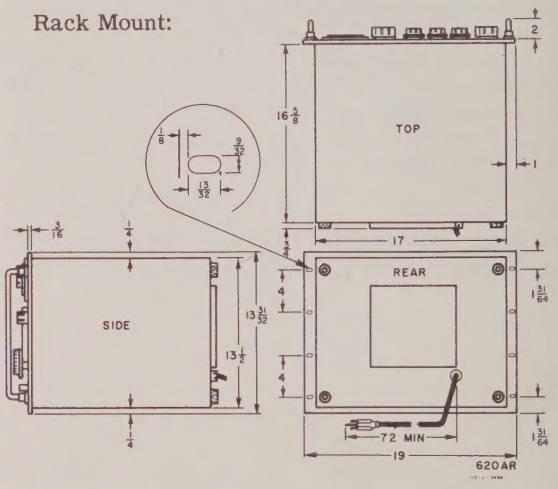
EXTERNAL PULSE MODULATION:
Pulse requirements: amplitude from 20 to 70 volts positive or negative, width 0.5 to 2500 microseconds.

EXTERNAL FREQUENCY MODULATION:
Provides capacitive coupling to repeller of klystron. Maximum deviation approximately ±2.5 mc.

POWER SOURCE:
115/230 volts ±10%, 50 to 60 cps, 250 watts.

SIZE:
Cabinet Model: 17-1/8" wide, 13-7/8" high, 17-5/8" deep.

Rack Mount:



WEIGHT:
Cabinet Model: 94 lbs., shipping 170 lbs.
Rack Mount: 94 lbs., shipping 170 lbs.

ACCESSORY SUPPLIED:
℗ AC-16Q Cable Assembly, 6 feet of specially treated RG-9A/U 50 ohm coaxial cable terminated at each end with UG-21D/U type N male connectors.

ACCESSORY AVAILABLE:
℗ AC-16K Cable Assembly, 4 feet of RG-58/U 50 ohm coaxial cable terminated at each end with UG-88/U Type BNC male connector.

SECTION I

GENERAL DESCRIPTION

1-1 INTRODUCTION

The Model 620A SHF Signal Generator is designed to generate voltages in the frequency range from 7000 to 11,000 megacycles. At least one milliwatt power output is available across the band. The output frequency is indicated on a direct reading dial. The attenuator controlling the output level is calibrated in microvolts and decibels.

The flexibility of rf output control is described in the following capabilities:

UNMODULATED (CW)

INTERNAL PULSE MODULATION

Repetition rate variable from 40 to 4,000 pulses/sec. Pulse length variable from .5 to 10 microseconds as measured between points that are 50% of the maximum amplitude of the initial rise.

EXTERNAL PULSE MODULATION

External pulse modulation requires pulses having the following characteristics.

Amplitude	20 to 70 volts
Width	.5 to 2500 microseconds
Polarity	Positive or negative

INTERNAL FREQUENCY MODULATION

The sawtooth sweep rate is variable from 40 to 4,000 cycles/sec. The frequency deviation is variable from 0 to ±2.5 megacycles.

EXTERNAL FREQUENCY MODULATION

With a sine wave input, frequency deviation up to 10 megacycles can be obtained, depending on the frequency of the radio frequency oscillator.

INTERNAL SQUARE WAVE MODULATION

Variable from 40 to 4,000 cycles/sec.

SYNC OUT SIGNALS

a. (Delayed Sync Out) - A positive pulse simultaneous with the front of the rf pulse. Pulse amplitude at least 25 volts and rise time shorter than one microsecond. The output circuit is designed to work into a load of 1000 ohms or more.

b. (Undelayed) - Has the same characteristics as the delayed sync out signal except that the pulse precedes the front of the rf pulse by 3 to 300 microseconds.

Both the pulse and frequency modulated radio frequency output may be synchronized with the following externally generated signals.

1. Sine waves of 40 to 4,000 cycles/sec. and 5 to 50 volts (RMS) amplitude.

2. Pulses of 0 to 4,000 pulses/sec., a peak amplitude of 5 to 50 volts, a rise time of .1 to 1 microsecond, and a width of .5 to 5 microseconds.

1-2 DAMAGE IN TRANSIT

After unpacking the instrument, should any shipping damage be discovered, follow the procedure described in the "Claim for Damage" section on the last page of this manual.

1-3 ATTENUATOR CALIBRATED AT PANEL JACK

The accuracy of the output system and the calibration of the attenuator in the Model 620A is determined at the front panel output jack. Output cable losses must be considered in addition to the attenuator dial indication when employing specific signal levels at the end of the output cable.

1-4 CAUTION

Do not connect rf or dc power in any magnitude to the output terminals of this instrument. As little as 1/5 watt can either severely damage or burn out the attenuator probe.

WARNING

Extreme care should be exercised when working with transceiver types of equipment to insure that the transmitter section is not operating while the Model 620A is connected to the antenna.

Erratic instrument performance at the output terminals, or even no power output is frequently an indication that the instrument has been subjected to the abuse described above. This condition may be confirmed by measuring either the dc resistance of the attenuator or the SWR looking into the panel connector.

dc resistance = approximately 50 ohms SWR (at panel connector) = 2.0 or better.

If investigation shows an attenuator burn out, the probe assembly must be replaced.

1-5 230 VOLT OPERATION

Should it be desired to operate the Model 620A from a 230 volt source, proceed as follows:

a. Remove the following jumpers:
T301 - 1A to 3A and 2A to 4A
T302 - 1 to 3 and 2 to 4

b. Install the following jumpers:
T301 - 2A to 3A
T302 - 2A to 3A

c. Change the line fuse F 301 to one of a 1.6 ampere slow blow rating.

As shown in the schematic diagram, this alteration changes the primary windings of the power transformer from a parallel arrangement to a series arrangement.

1-6 POWER CABLE

The three conductor power cable supplied with this instrument is terminated in a polarized three-prong male connector recommended by the National Electrical Manufacturers' Association. The third contact is an offset pin, added to a standard two-blade a-c connector, which grounds the instrument chassis when used with the appropriate receptacle. To use this NEMA connector in a standard two-contact receptacle, an adapter will be required. The ground connection emerges from the adapter as a short lead which should be connected to ground for the protection of operating personnel.

1-7 KLYSTRON TUBE WARRANTY AND REPLACEMENT PROCEDURE

A klystron warranty claim has been included in this manual and is located at the rear of the Table of Replaceable Parts. When replacing a klystron tube which has failed prior to the expiration of the guarantee, fill out the claim sheet and return it with the tube to the company from which the tube was obtained. A new sheet will be furnished with each replacement tube purchased from Hewlett-Packard.

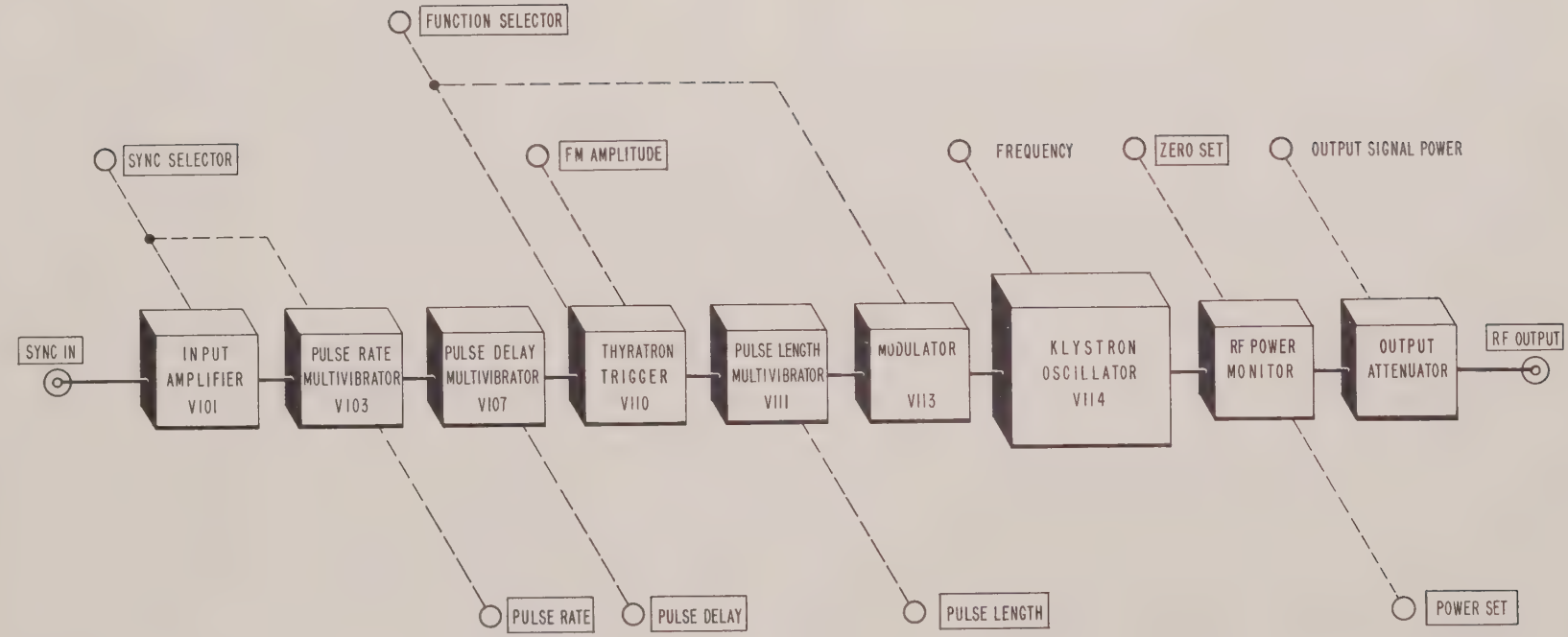


Fig. 2-1 Block Diagram Showing Operating Controls

SECTION II

OPERATING INSTRUCTIONS

2-1 OPERATING PRECAUTION

This equipment employs high voltages (1500 volts) which are dangerous to life. Although bleeder circuits are used to prevent capacitors from retaining charges after the power has been disconnected, always discharge and ground circuits before touching them in order to avoid casualties. The klystron used in this instrument is expensive and has a shorter life than that of the conventional vacuum tube. Average klystron life approximates 1,000 hours. Power should be removed from the signal generator when it is not in actual use in order to increase the useful life of the klystron.

2-2 CONTROLS AND TERMINALS

ON
This toggle switch controls all power to the instrument.

POWER
When this red light is on it indicates that power is being supplied to the instrument.

SIGNAL FREQUENCY
This control is used to adjust the operating frequency of the shf oscillator to the desired output frequency. The frequency is read on the MEGACYCLES dial above the control. A 360° vernier scale graduated from 0 to 100 is provided on the control itself so that accurate resetting to a specific frequency can be made.

ZERO SET
This control is used to set the needle of the POWER SET meter to the zero position when the MOD. SELECTOR switch is in the OFF position and the power switch is in the ON position.

POWER SET
This control is used to set the needle of the POWER SET meter to 0 db (red line at center of scale) prior to adjusting the attenuation. It also moves the index over the OUTPUT ATTEN (attenuator) dial to establish the reference level for reading the attenuator dial.

OUTPUT ATTEN

This control determines the attenuation of the radio frequency output of the signal generator. It also operates the OUTPUT ATTEN dial so that the reading of this dial under the index indicates the output level of the signal generator in voltage and in decibels below one milliwatt.

FM AMPLITUDE

This control adjusts the deviation (frequency swing) of the output frequency from 0 to ±3 megacycles from the center (CW) frequency when frequency modulation is employed.

MOD. SELECTOR

This switch is located in the upper left hand corner of the front panel of the signal generator. It has the following positions:

a. EXT FM. When in this position, the signal generator circuits are switched so that an external sine or saw-tooth voltage may be applied to the EXT. MOD input connector to provide externally modulated output.

b. INT. FM. When in this position, the signal generator circuits are switched so that saw-tooth type frequency-modulated pulses are provided. When the SYNC SELECTOR switch is in the X1 or X10 position, these pulses are initiated by the internal pulse generating circuits of the signal generator.

c. CW. When in this position, the output of the signal generator is continuous wave.

d. OFF. When in the OFF position, the r-f oscillator tube is biased off so that the signal generator will provide no output. This position is provided to permit the POWER SET meter to be zero set before each test by adjustment of the ZERO SET control. However, filament and plate voltages remain applied to all tubes so that the signal generator may be instantly operative when this switch is moved to one of its other positions.

e. INT. When in this position, the pulse repetition frequency is indicated by the position of the PULSE RATE control when the SYNC SELECTOR switch is in the X1 position. When the SYNC SEL switch is in the X10 position, the pulse rate will be 10 times the rate indicated by the calibrations of the PULSE RATE control.

f. EXT. +. When in this position, the signal generator may be modulated by positive external pulses or square waves applied to the EXT. MOD connector on the front panel.

g. EXT. -. When in this position, the signal generator may be modulated by negative external pulses or square waves applied to the EXT MOD connector on the front panel.

h. SQ. WAVE. When in the SQ. WAVE position, the output signal generator will be square waves of radio frequency voltage. The repetition rate of these pulses will be determined by the adjustment of the PULSE RATE control and the SYNC SELECTOR switch in the X1 or X10 position and will be between 40 and 4,000 pulses per second. The "on" time will be approximately equal to the "off" time.

PULSE WIDTH

The adjustment of this calibrated control determines the width of the main output pulse when the MOD SELECTOR switch is in the INT position and the SYNC switch is in the EXT +, EXT -, ∿, X1 or X10 positions.

PULSE DELAY

This control determines the time delay between the start of the synchronizing pulse and the start of the radio frequency output pulse delivered by the signal generator. The control permits insertion of delays from 3 to 300 microseconds following the synchronizing pulse. This same delay period will also be present between the pulse appearing on the SYNC OUT connector and the DELAYED SYNC OUT connector on the control panel.

PULSE RATE

The setting of this control determines the pulse repetition frequency of the internal pulse generating circuits when the MOD SELECTOR switch is in the INT, INT FM or SQ WAVE position and the SYNC SELECTOR switch is in either the X1 or the X10 position. When the SYNC SELECTOR switch is in the X1 position, the pulse repetition rate is as read on the calibrated dial of the control. When the SYNC SELECTOR switch is in the X10 position, the reading of the pulse rate control must be multiplied by 10 to indicate pulse repetition rate.

SYNC SELECTOR

This switch determines the type of synchronization that is to be employed by the signal generator. It has the following positions:

a. ∿. When the switch is in this position, and the MOD SELECTOR switch is in the INT position, the signal generator may be

synchronized by external sine wave voltages with an amplitude between 5 and 50 volts rms, applied to the SYNC IN connector on the front panel.

b. EXT-. When the switch is in this position, and the MOD SELECTOR is in the INT position, the signal generator must be synchronized by external negative voltage pulses of an amplitude between 5 and 50 volts applied to the SYNC IN connector on the front panel.

c. EXT +. When the switch is in this position, and the MOD SELECTOR switch is in the INT position, the signal generator must be synchronized by external positive voltage pulses with an amplitude of between 5 and 50 volts applied to the SYNC IN connector on the front panel.

d. X1. When the SYNC SEL switch is in this position, and the MOD SELECTOR switch is in the INT position, the internal pulse generator is free-running. The repetition rate is as read directly on the PULSE RATE control.

e. X10. When the SYNC SELECTOR switch is in this position, and the MOD SELECTOR switch is in the INT position, the repetition rate of the synchronizing pulses is as read on the dial of the PULSE RATE control multiplied by 10.

2-3 OPERATING INSTRUCTIONS, GENERAL

Operating this instrument can be divided into two parts: adjusting the r-f section, and adjusting the modulator section. In general, it is desirable first to adjust the r-f section, since this adjustment establishes the reference level for the output power-monitoring system. The following procedures assume that the instrument has been energized and allowed to reach a stable operating temperature for a period of at least 5 minutes. If ambient temperature is below about 10° C (50° F), a longer warm-up period is desirable.

2-4 ADJUSTING THE R-F SECTION TO OBTAIN CW OUTPUT

a. Tune the signal generator to the desired frequency with the SIGNAL FREQUENCY control.

b. Set MOD SELECTOR switch to OFF position and adjust ZERO SET control so that POWER SET meter needle is exactly over the ZERO SET index line on the meter.

c. Place MOD SELECTOR switch to the CW position.

d. Adjust POWER SET control to obtain "0" dbm on POWER SET meter.

e. Adjust the OUTPUT ATTEN control to the desired value of attenuation as indicated by the OUTPUT ATTEN dial under the index.

NOTE

For a given setting of the OUTPUT ATTENUATOR dial, the indicated peak voltage of the r-f output under conditions other than CW will be within ±1 decibel of that for CW operation.

2-5 MODULATED OUTPUT

The signal generator, for the purpose of the following adjustments, is assumed to be warmed-up and adjusted as described above. The following paragraphs outline the adjustment of the controls and connections of the cables in order to obtain various types of modulated output.

2-6 SQUARE WAVE OUTPUT

a. Set MOD SELECTOR switch to SQ WAVE position.

b. Set SYNC SELECTOR switch to the X1 or X10 position and set PULSE RATE control as necessary to obtain desired repetition rate.

c. Connect the r-f cable between RF OUTPUT connector on the signal generator and equipment being tested.

d. A sync pulse is available at the SYNC OUT connector for each cycle of the square wave.

2-7 INTERNAL PULSE MODULATION

a. Set MOD SELECTOR switch to INT position.

b. Set SYNC SELECTOR switch to X1 or X10 and set PULSE RATE control as necessary to obtain desired pulse repetition rate.

c. Set PULSE WIDTH control to obtain desired pulse width.

d. Set PULSE DELAY control to obtain desired delay.

e. Set FM AMPLITUDE control to OFF position.

f. Connect r-f cable between RF OUTPUT connector and load.

g. Connect video cable between the SYNC OUT and/or DELAYED SYNC OUT connectors and external equipment as required by the application.

2-8 INTERNAL FREQUENCY MODULATION

a. Set MOD SELECTOR switch to INT FM position.

b. Set the SYNC SELECTOR switch to X1 or X10 position and set PULSE RATE control so that desired repetition frequency will be obtained.

c. Set FM AMPLITUDE control to OFF position; then SLOWLY advance the control to a position between OFF and maximum to establish the desired degree of FM about the center frequency. Because of the characteristics of the klystron, unstable operation will occur when the control has been advanced so that the f-m deviation is greater than the stable portion of the mode.

d. Connect r-f cable between RF OUTPUT connector on signal generator and load.

e. If desired, connect video cable between SYNC OUT connector and external equipment.

2-9 EXTERNAL PULSE MODULATION

a. Set MOD SELECTOR switch to the EXT + or EXT — position, as required by the polarity of the external modulating pulse available.

b. Connect external modulation pulse to the EXT MOD connector on the front panel. External pulse should have an amplitude of at least 20 volts peak.

c. No output pulses other than the r-f output are available under this condition.

2-10 EXTERNAL FREQUENCY MODULATION

a. Set the MOD SELECTOR switch to EXT FM position.

b. Connect external modulation voltage to the EXT MOD connector on the front panel. A source voltage of 20-30 volts rms is desirable.

c. Set FM AMPLITUDE control to OFF position; then SLOWLY advance the control to a position between OFF and maximum to establish the desired degree of FM about the center frequency. Because of the characteristics of the klystron, unstable operation will occur when the control has been advanced so that the f-m deviation is greater than the stable portion of the mode.

d. No output other than r-f output is available under these conditions.

SECTION III

CIRCUIT DESCRIPTION

3-1 GENERAL

As seen in the block diagram, the Model 620A Signal Generator consists of the following basic sections:

SYNCHRONIZING CIRCUITS - to establish the repetition rate of the modulation pulse applied to the r-f oscillator.

MODULATOR - to develop a positive pulse to be applied to the klystron modulator grid.

R-F OSCILLATOR - which receives the positive modulation pulse and generates the r-f output pulse.

OUTPUT ATTENUATOR - a coupling system that adjusts the r-f output to the desired power level.

POWER MONITOR - to monitor the power level existing in the r-f oscillator and to provide a reference from which to calibrate the output power level.

POWER SUPPLY - which develops the operating voltages employed by the electronic components of the generator.

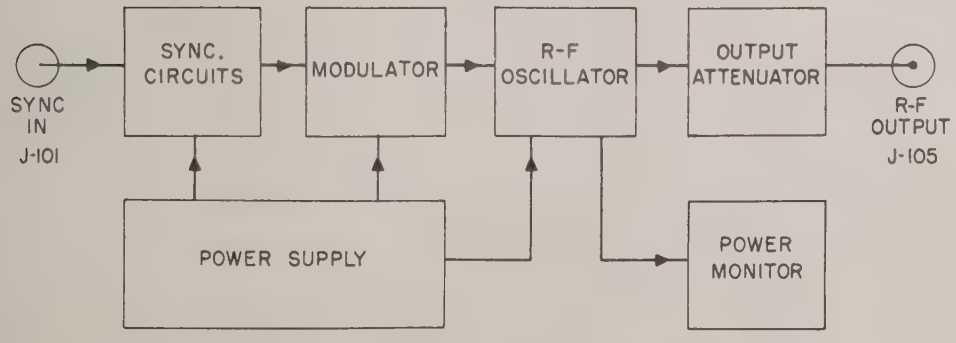


Fig. 3-1 Circuit Block Diagram

3-2 SYNCHRONIZING CIRCUITS

These circuits accept the external synchronizing voltage applied at J-101 the SYNC IN connector, and transform it into a negative pulse employed to trigger the pulse rate multivibrator V-103. The circuit elements are shown in figure 3-2. V-101A is 1/2 of a type 12AT7 dual triode. The grid is returned to B+ (ground). This places the grid at zero bias and the tube is drawing current through plate load resistor R-103. The tube responds to both positive and negative signals.

The negative-going portion of a sine wave synchronizing voltage, or a negative sync pulse, causes the tube to cut off, developing a positive pulse in its plate circuit. This is applied to the grid of V-101B. V101B is cut off with a bias of -15 volts and the positive pulse from the plate of V-101A causes V-101B to conduct, thus its plate voltage drops and the output is a negative going pulse with steep leading edge.

This negative pulse is applied to the ∿ and (-) contacts of the SYNC SELECTOR switch S-101A through the series diode clipper V-102A. V-102A acts to apply only negative pulses to following circuits.

When a positive external sync pulse is applied to the grid of V-101A, a negative pulse is developed in its plate circuit and applied to the + contact of S-101A by capacitor C-103.

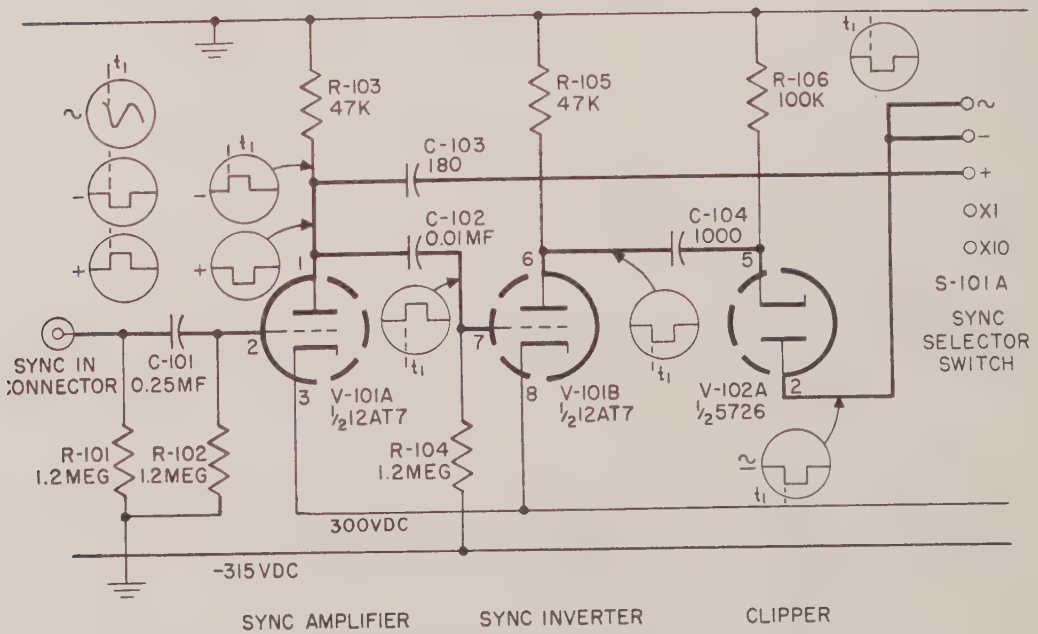


FIG. 3-2 BASIC SYNC INPUT CIRCUITS

PULSE RATE MULTIVIBRATOR (SYNC CONDITION)

When external sine wave sync signals are employed, the sync multivibrator is switched to the operating condition shown in figure 3-3. This circuit is standard one-shot multivibrator with V-103A drawing current as its grid is returned to its cathode while V-103B is cut off, its grid being returned to the -360 vdc line.

The negative pulse from the sync input circuits causes the multivibrator to switch at t_1 developing a negative pulse in the plate circuit of V-103B. The width of the pulse is determined by the length of time necessary to discharge capacitor C-111 through R-115.

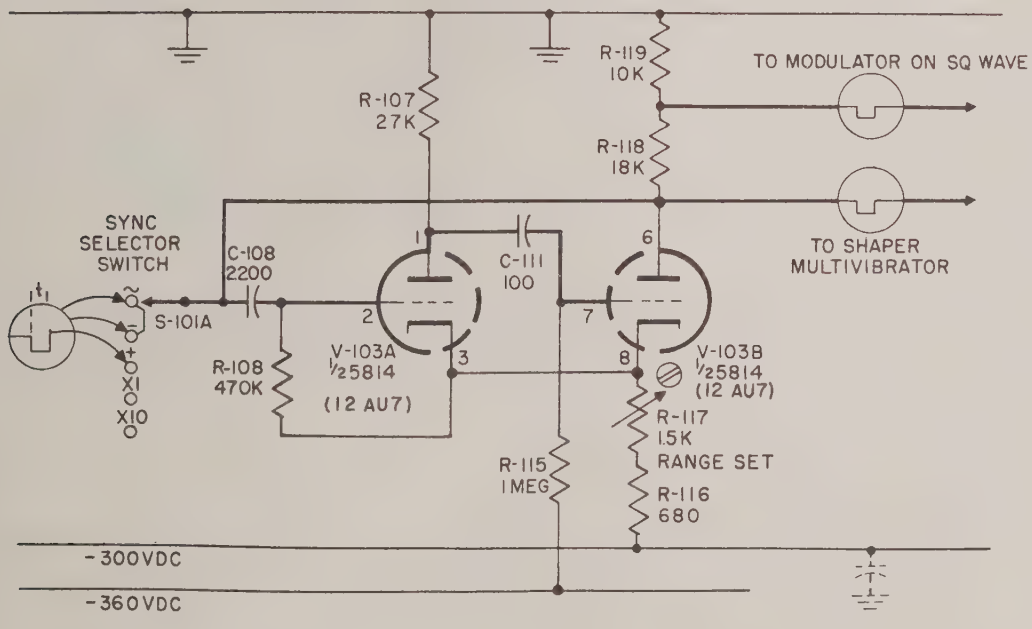


Fig. 3-3 Basic Pulse Rate Multivibrator, External Sine Wave Sync Condition

PULSE RATE MULTIVIBRATOR (FREE-RUNNING CONDITION)

In the INT FM, INT (pulse), and SQ WAVE positions of the modulation selector switch S-102, the pulse rate multivibrator is converted to a free-running multivibrator (figure 3-4). Under this condition the sync input circuits are disconnected from the rate multivibrator.

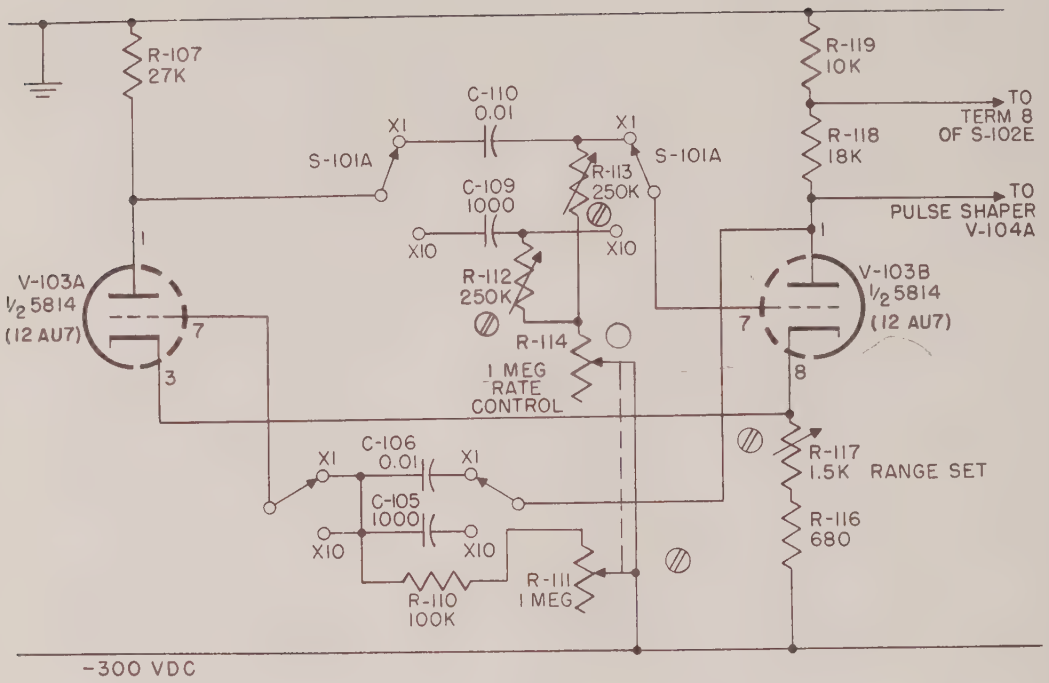


Fig. 3-4 Basic Pulse Rate Multivibrator

The time constants of the multivibrator are balanced so that the circuit generates a wave that is essentially square with approximately a 50% duty cycle; however, this may vary depending upon the repetition rate. This arrangement is used so that internal square wave as well as internal pulse modulation of the r-f oscillator can be obtained. The arrangement also provides for equally-spaced pulses to trigger the sawtooth generator when internal sawtooth f-m modulation is desired.

A square wave voltage of full amplitude is taken from the plate across R118 and R-119 for the pulse shaper while one of approximately one-third the amplitude is taken across R-119 for application to the modulator when the MOD SELECTOR switch is in the SQ WAVE position. This output to the modulator is employed only when square wave modulation is desired.

3-3 MODULATOR SECTION

The modulator section is shown in block diagram form in figure 3-5. The function of the circuits in this section are to es-

tablish a modulating pulse (for pulse operation) or a sawtooth voltage (for frequency modulation) and to apply it to the r-f oscillator so as to secure the desired type of r-f output.

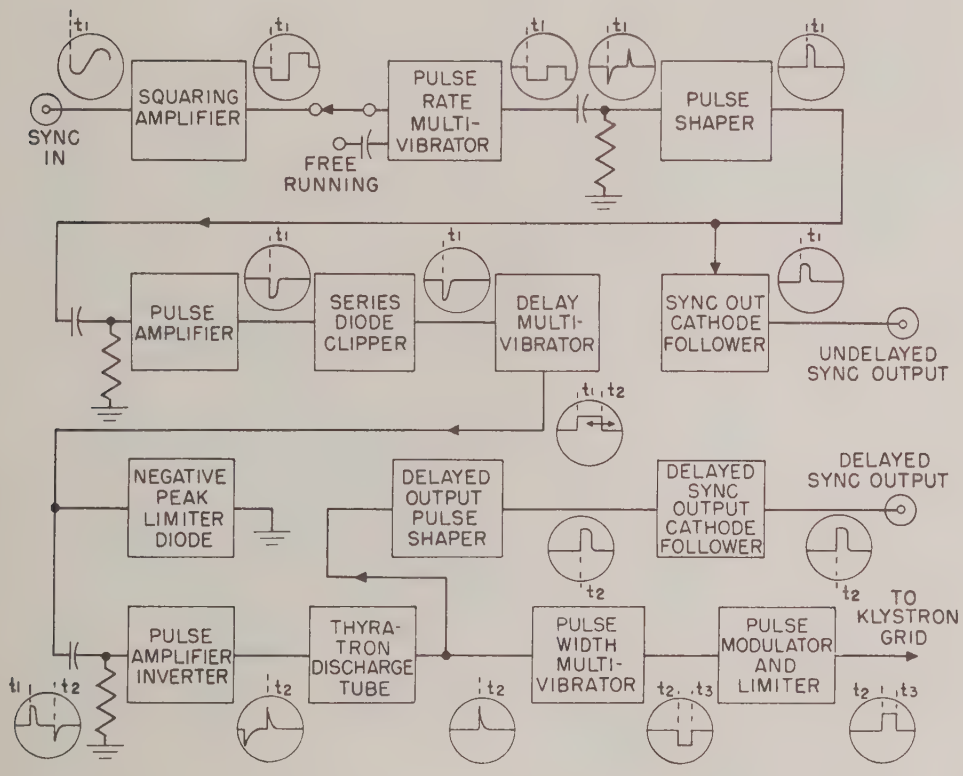


Fig. 3-5 Block Diagram of Modulator Circuit

Various portions of these circuits are not employed in certain types of operation such as when external pulse or frequency modulation voltages are provided. However, the block diagram shows the condition where all of the circuits are employed (delayed pulse output with external synchronization) and the description will cover this type of operation. Other types of operation will be described in later paragraphs.

PULSE SHAPER

The pulse shaper (figure 3-6) is a one-shot multivibrator with a two-microsecond pulse duration. It consists of V-104A and

V-104B, two halves of type 5814 dual triode. In the steady-state condition, V-104A is drawing current as its grid is returned to the cathode by resistor R-121. V-104B is cut off as its grid is returned to -300 vdc, thus placing a bias on the grid developed by the flow of current through V-104A and cathode resistor R-120.

When this multivibrator is triggered by the negative going leading edge of the wave generated by the pulse multivibrator, a positive voltage pulse appears at the plate of V-104A. The pulse width is narrow, essentially two microseconds.

The positive output pulse is applied to the sync amplifier tube V-105A shown in figure 3-7 and to sync out cathode follower V-105B shown in figure 3-6.

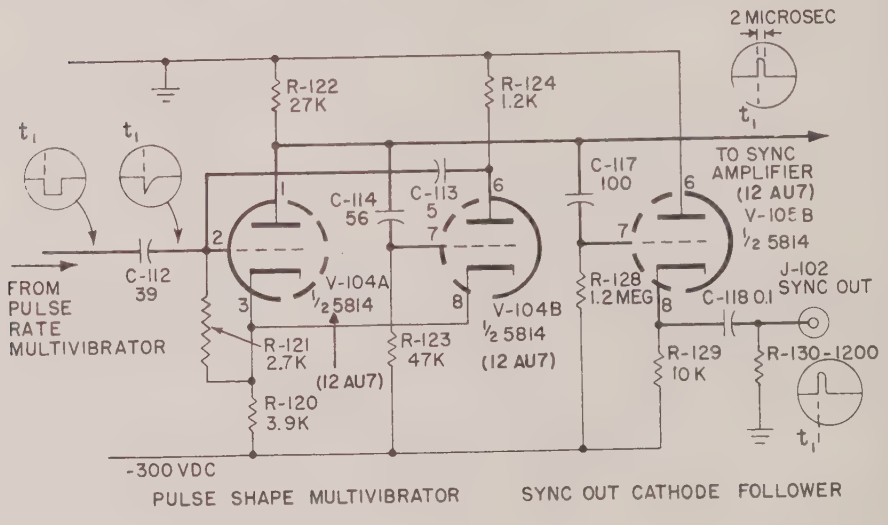


Fig. 3-6 Pulse Shaping Multivibrator and Sync Out Cathode Follower

SYNC OUT CATHODE FOLLOWER

This stage provides the undelayed sync output signal for synchronizing external equipment. It is a standard cathode follower comprised of V-105B, one half of a type 5814 dual triode tube. The output is taken across R-129, the cathode resistor, and is capacitively coupled to the SYNC OUT connector J-102 by C-118. Resistor R-130 is returned from the center conductor of the connector to ground so that the line is termin-

ated in reference to ground instead of the 300 vdc potential existing at the base of the cathode resistor.

The output of the cathode follower is a positive pulse greater than 25 volts when applied to a load having a resistance of from 1000 to 100,000 ohms and a shunt capacitance of 500 mmf.

PULSE AMPLIFIER

The pulse amplifier is comprised of V-105A, one-half of a type 5814 tube as shown in figure 3-7, and its associated components. It amplifies and inverts the two-microsecond pulse provided by the pulse shaper and provides negative pulse at t_1 it its plate circuit. It also provides a positive-going pulse in its cathode circuit from C-115 that is employed to trigger the sawtooth generator when internal frequency modulation is employed. C-115 acts as a cathode bypass capacitor when internal pulse modulation is employed.

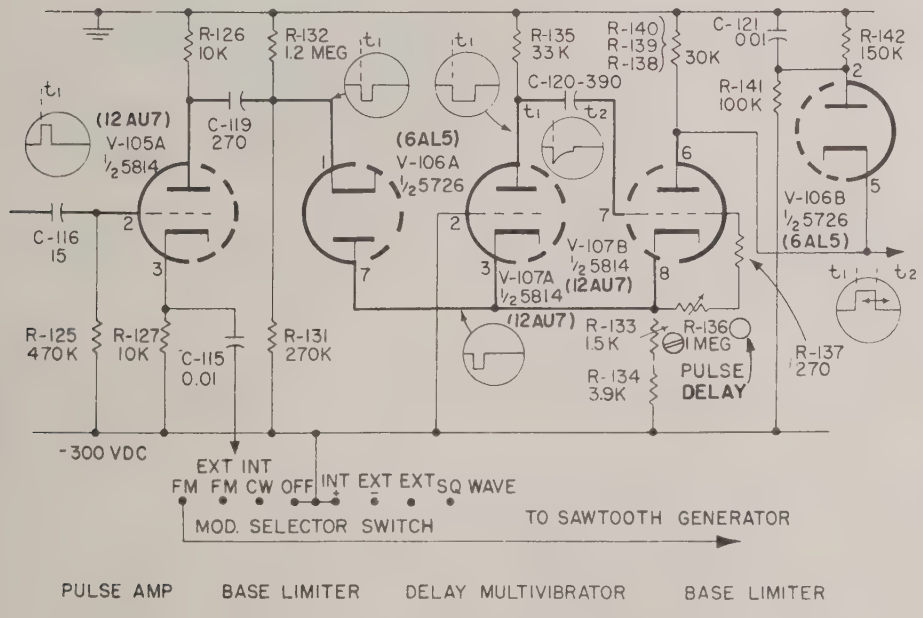


Fig. 3-7 Pulse Amplifier and Delay Multivibrator

SERIES DIODE BASE LIMITER

The negative pulse from the plate of the pulse amplifier is applied to the cathode of the diode limiter V-106A shown in figure 3-7. This limiter is so connected that only the negative

components with an amplitude greater than the bias on the diode will pass on to the cathode of the delay multivibrator. This prevents triggering the multivibrator by any positive or low amplitude negative transients that may appear on the output of V-105A in addition to the desired trigger pulse.

DELAY MULTIVIBRATOR

This circuit (Figure 3-7) provides an adustable time delay in applying the modulation to the r-f oscillator. It consists of type 5814 dual triode V-107 connected as a one-shot multivibrator with an adjustable resistor R-136, PULSE DELAY control.

The multivibrator starts its cycle when a negative pulse drives the cathode of V-107A in a negative direction. This is equivalent to placing a positive signal on the grid, and the tube draws current. A negative wave front appears at the plate of V-107A and through Capacitor C-120, drives the grid of V-107B in a negative direction, cutting off this half of the stage. The length of time the circuit will require before returning to its resting condition will be determined by the time constant of C-120, R-136 and R-137. R-136 is the calibrated PULSE DELAY panel control that adjusts the delay from 3 to 300 microseconds, while R-133 is a chassis adjustment used to set the maximum delay to 300 microseconds.

In the steady-state condition V-107A is cut off while V-107B is drawing current through its plate load resistors R-138, R-139 and R-140 in parallel with R-142 and the diode V-106B.

V-106B serves as a negative base limiter which eliminates low amplitude negative pulses that may otherwise follow the trailing edge of the main pulse from V-107B.

PULSE AMPLIFIER-INVERTER

This stage shown in Figure 3-8 is comprised of V-109A, one-half of a type 5814 dual triode. The positive pulse from the pulse delay multivibrator is differentiated by capacitor C-122 and resistor R-187 to form a sharp negative spike at t_2. These are amplified and inverted in the plate circuit of V-109A.

BLOCKING DIODE

The output of V-109A is applied to the grid of the thyratron discharge tube V-110 through blocking diode V-108B. The purpose of V-108B is to pass the positive output spike at t_2 and to block the negative spike at t_1. At short delays this insures positive triggering of the thyratron V-110.

THYRATRON DISCHARGE TUBE

This stage consists of the type 2D21 thyratron tube V-110 shown in figure 3-8. Its grid is returned to approximately -315 volts while the cathode is returned to -300 volts, cutting off the tube. Capacitor C-127 is charged to approximately 110 volts positive to the cathode, a point established by the values of R-148 and R-149 and diode V-108A. This device for limiting the voltage on C-127 is necessary due to wide variation in the pulse repetition frequency of the unit and the fact that the capacitor will charge exponentially with time.

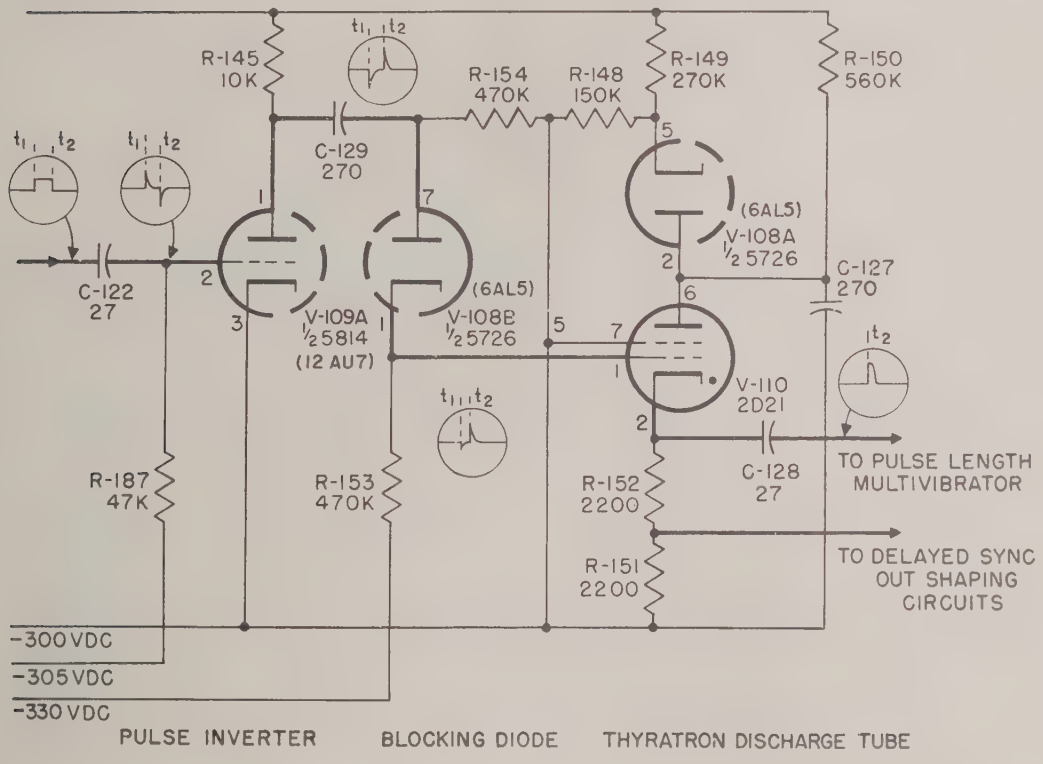


Fig. 3-8 Thyratron Discharge Circuits

This would result in the capacitor charging to a higher potential at the low repetition frequencies than at the higher frequencies. The diode circuit limits the charge to a value that can be reached at the highest repetition frequencies, and prevents it from going higher regardless of the charging time available.

When the positive pulse of voltage from V-109A reaches the grid, the gas in the tube ionizes and C-127 discharges through the tube, and cathode resistors R-157 and R-152 in series. This causes a positive pulse to appear across the cathode resistors.

When C-127 is nearly discharged and the plate voltage is at a very low value the gas in the tube deionizes and the tube returns to the resting condition. By this time the pulse on the grid has decayed and the grid bias is again -315 volts.

C-127 is rapidly recharged to its resting voltage of approximately 110 volts and is maintained at this value through the action of the diode circuit explained above.

The spike occurring in the cathode circuits at t_2 is applied to the pulse length multivibrator and to the delayed sync pulse output circuits.

DELAYED OUTPUT PULSE SHAPER AND CATHODE FOLLOWER

Figure 3-9, the delayed output shaper, is a multivibrator comprised of the two triode sections of the type 5814 tube V-115. One half the type 5814 dual triode tube, V-109B, is connected as a cathode follower. The positive spike developed in the cathode circuit of the thyratron discharge tube is applied to grid of V-115A through capacitor C-138 at time t_2.

The section of the multivibrator formed by V-115A is cut off, its negative bias being established by current of V-115B flowing through cathode resistor R-195.

The section comprised of V-115B is drawing current in the resting condition as its grid is returned to the cathode through R-194. The positive leading edge of the pulse from V-110 causes the multivibrator to switch, cutting off current through V-115B and causing the voltage at its plate to rise.

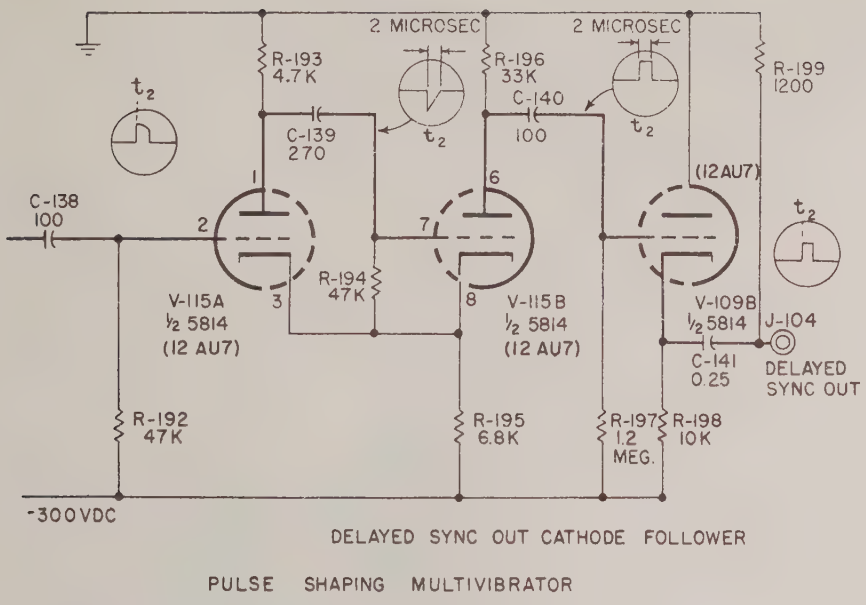


Fig. 3-9 Pulse Shaping Multivibrator and Delayed Sync Out Cathode Follower

The time constant of the circuit is approximately two microseconds. At the end of this time capacitor C-139 is discharged through R-194 and R-195 to a point where V-115B again draws current and completes the cycle. The output at the plate of V-115B is a positive pulse of approximately two microseconds duration. This is coupled to V-109B, the cathode follower.

V-109B is a conventional cathode follower employed as an impedance transformer, receiving the pulse from the high impedance plate of the multivibrator and delivering it to the relatively low impedance across the DELAYED SYNC OUT panel connector J-104 for synchronizing external equipment at t_2.

PULSE LENGTH MULTIVIBRATOR

The pulse length multivibrator shown in figure 3-10 is a one-shot multivibrator employing a type 5814 tube V-111. The circuit employs capacitive cathode to cathode coupling to secure the necessary interstage action. This avoids any feedback connection to the plate of V-111A, reducing stray capacitance that would tend to slow down the voltage rise and fall. Peaking inductance L-101 is also employed in the plate circuit from which the output is taken to further steepen the wave front.

In the steady-state condition, V-111A is biased beyond cut off while V-111B is drawing current as its grid is returned to B+ (ground).

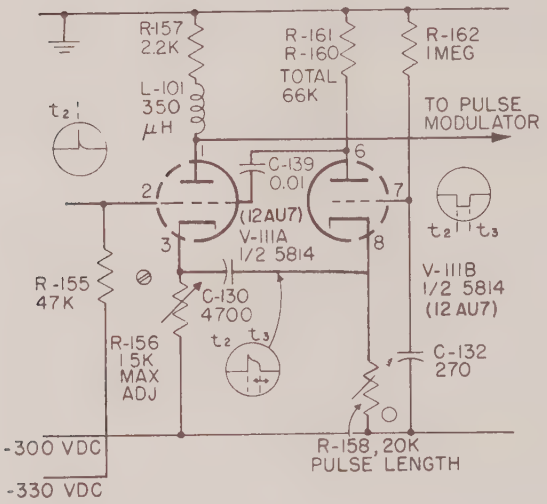


Fig. 3-10 Pulse Length Multivibrator

When the positive pulse at t_2 is applied to the grid of V-111A, it immediately draws current, causing the V-111A side of C-130 to rise to the potential set up by the current flowing through R-156. R-156 is adjustable, and the amount of this rise is determined by the resistance. R-156 acts as a maximum delay time adjustment for the circuit.

The voltage rise across R-156 is applied to the cathode of V-111B causing it to become more positive with respect to grid 7. This cuts off the tube rapidly since the grid is maintained at essentially the cathode potential due to the time constant of R-162 and C-132.

Capacitor C-130 is now charged in a positive direction and commences to discharge. The time constant of this discharge to the point where V-111B will again draw current, determines the duration of the negative output pulse. The width is adjusted by R-158 which is the calibrated PULSE WIDTH panel control. This

control can be adjusted to provide pulses of from 0.5 to 10 microseconds duration.

The output of the pulse length multivibrator is a negative pulse starting at t2 and ending at t3. This negative pulse is applied to the pulse modulator tube V-113.

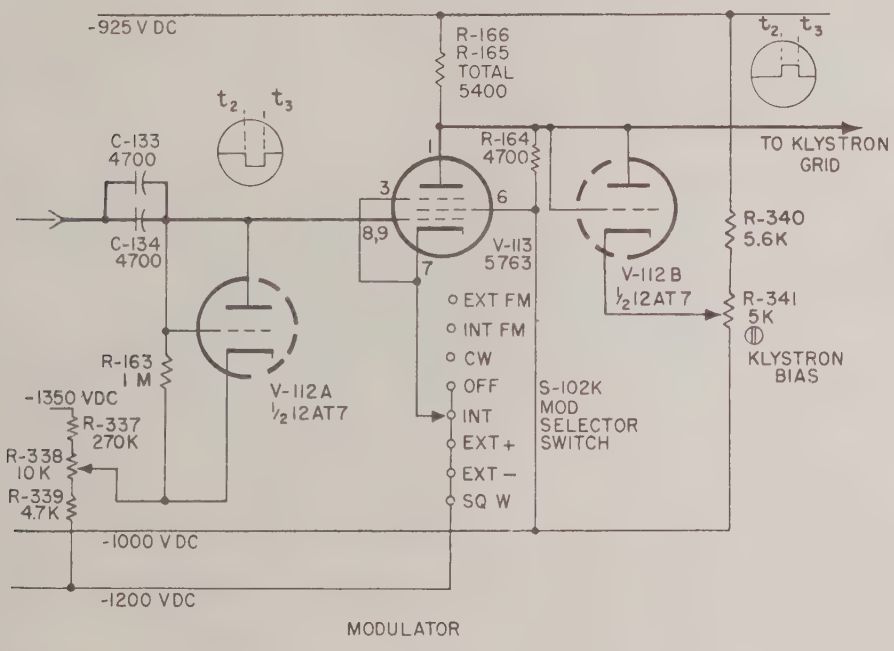


Fig. 3-11 Klystron Modulator Circuit

KLYSTRON

The klystron modulator circuits shown in Figure 3-11 consist of V-113, type 5763 pentode amplifier, and V-112A, one-half of a type 12AT7 dual triode connected as a positive peak clipper. V-112B, the other triode is diode-connected, and provides a fixed operating bias for the control grid of the klystron r-f oscillator tube V-114.

The positive pulse from the pulse width multivibrator is coupled to the control grid of V-113 by C-133 and C-134 in parallel. Bias for the grid is adjusted by potentiometer R-338 in the power supply, so that the flow of current in the modulator is sufficient to cut off the klystron.

The adjustment of R-341 determines the maximum positive voltage applied to the grid of the klystron when the modulation pulse is present.

INTERNAL FREQUENCY MODULATION

When the MOD SELECTOR switch S-102 is in the INT FM position, the thyratron discharge tube is switched to comprise a conventional relaxation oscillator as shown in figure 3-12. This oscillator develops a sawtooth voltage wave that is applied to the r-f oscillator repeller.

C-124, C-125 and C-126 with resistors R-146 and R-147 determine the time constant of the sawtooth output for the X1 range while C-126, R-146 and R-147 perform the same function for the X10 range. R-147 is ganged with R-111 and R-114 and adjusted by the calibrated PULSE RATE panel control so that the f-m sweep rate and the internal pulse repetition rate may be controlled by the same knob.

The relaxation oscillator is triggered by a positive pulse from the cathode of the pulse shaper and when activated, delivers a rising sawtooth voltage to the repeller, sweeping the frequency and providing a sawtooth frequency modulation.

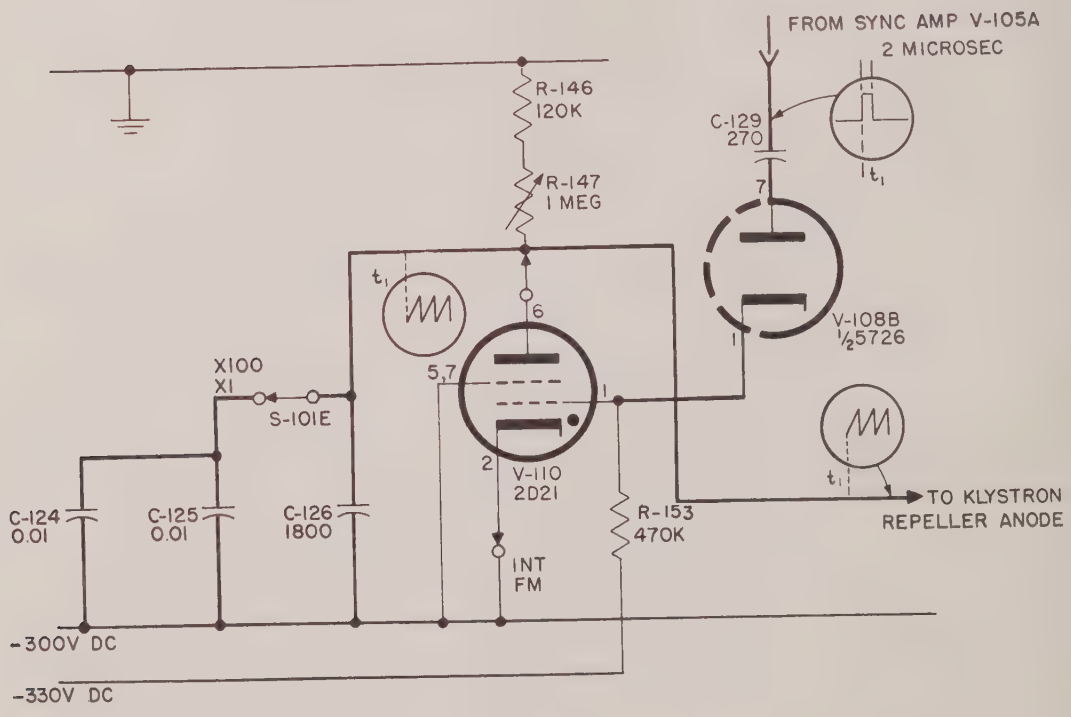


Fig. 3-12 Internal Frequency Modulating Circuit

3-4 RF OSCILLATOR

REFLEX KLYSTRON

The rf oscillator is a reflex klystron V-114 operating with a tunable coaxial line resonator. The resonant section is coupled to the resonator grids of the klystron as shown in Fig. 3-13, and in the equivalent circuit, Fig. 3-14.

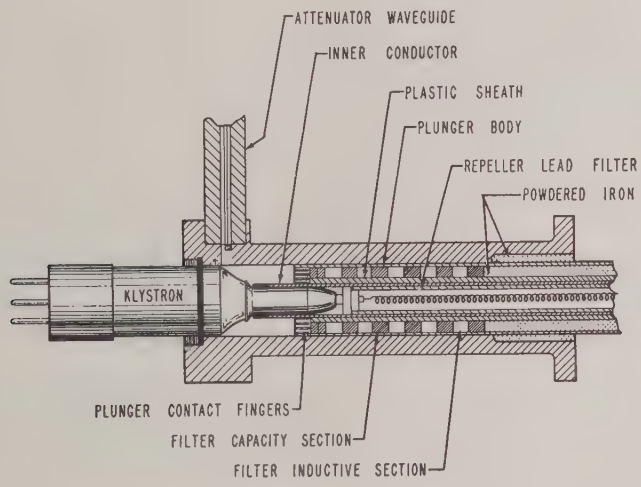


Fig. 3-13 Cross Section of RF Oscillator

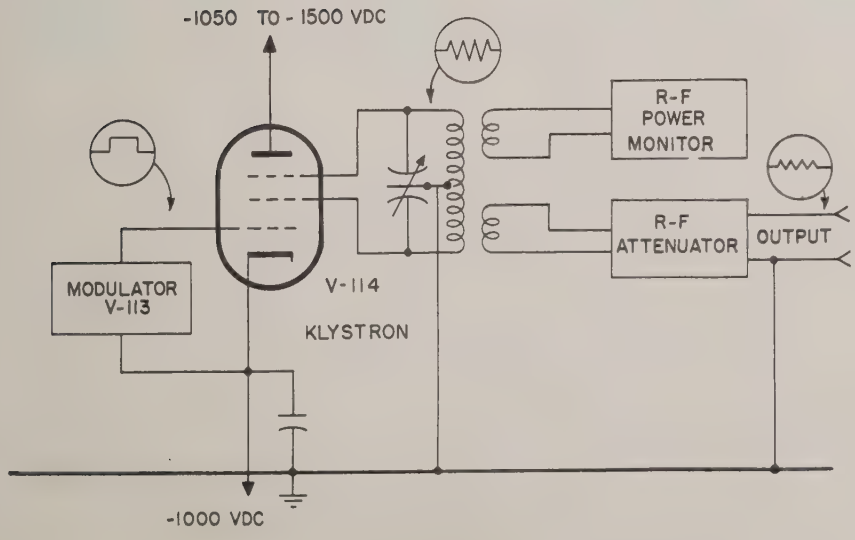


Fig. 3-14 Equivalent Circuit of R-F Oscillator

It may be seen how oscillation occurs when it is assumed that a small amplitude rf voltage exists across the resonator grids which has its origin as thermal agitation noise. The electron stream directed through the resonator grids from the cathode will be velocity modulated by this small rf voltage. The stream will cease to be uniform in nature, and may be thought of as having some of its electrons accelerated and some retarded. The resultant stream in the drift space past the resonator grids will possess bunches of electrons, and is therefore said to be velocity modulated.

As this bunched stream, or velocity modulated stream moves toward the negative repeller it is turned about and shot back through the resonator grids. Since the stream is bunched, it produces an rf voltage across the grids.

If the transit time has been right this new rf voltage will be in phase with the very small thermal rf voltage initially across the grids. As a result it will strengthen the bunching effect on the following stream. Upon reflection, the following stream will again strengthen the resonator grid voltage. This process, however, does not continue indefinitely.

A point is ultimately reached where the fundamental component of the bunching current decreases in magnitude. It may be inferred, therefore, that a point exists where there is just sufficient reflected energy to satisfy the requirements for oscillation.

Assuming that stable oscillation exists in the system described above, suppose that a sudden change in repeller voltage is introduced. The transit time of the electron stream, as it enters and departs the repeller field, would be changed. The current bunching effect would change also, and a new rf voltage would be produced across the resonator grids. The velocity modulation would give way to a new value with the circuit oscillating at a new frequency.

The situation described above, is only valid for relatively small variations in repeller voltage. Excessive variations will alter the relationship between the resonator voltage and the transit time of the electron stream, producing dead spots of no oscillation or conditions of oscillation on undesired modes.

The term mode in this sense is used to describe two different but interrelated, characteristics. One mode is the characteristic of the cavity or line section resonator which is resonant at a series of frequencies when the effective electrical length of the line is 1/4 wavelength, 3/4 wavelengths, 5/4 wavelengths. These effective electrical lengths are termed resonator modes.

Another mode is the repeller mode which describes the round-trip transit time of the electron stream as expressed in the cycles of rf voltage across the resonator grids. It has been found that oscillations most easily occur when the transit time equals 3/4, 1-3/4, 2-3/4, 3-3/4, 4-3/4... rf cycles. It is to be remembered that these repeller modes are distinguished by different transit times rather than by different resonant frequencies, and that they are functions of repeller voltage. Generally, the value of the repeller voltage increases for a given mode as the mean klystron frequency is tuned upward.

When a specific repeller mode is desired throughout a given band of frequencies, the repeller voltage is adjusted against the plunger travel (of a tunable resonator, for example) to hold the transit time constant. Since the repeller mode is a function of transit time, it also remains constant.

A third use of the term mode, is oscillation mode, which is defined in terms of the repeller mode and the cavity mode. For example, an oscillation mode might be 3/4 wavelength cavity and 3-3/4 repeller.

REPELLER ACTION

As seen in Figure 3-15, the repeller mode for the Model 620A shifts from the 3-3/4 mode to the 4-3/4 mode.

The 3-3/4 repeller mode is used for the 7 to 9 KMC range, and the 4-3/4 repeller mode is used above 9 KMC.

The repeller voltage is controlled by a suitably tapered potentiometer which is ganged to track with the frequency tuning plunger; it includes a sensitive switch which steps the repeller voltage less negative at approximately 8800 megacycles to change the transit time to 4-3/4 rf cycles.

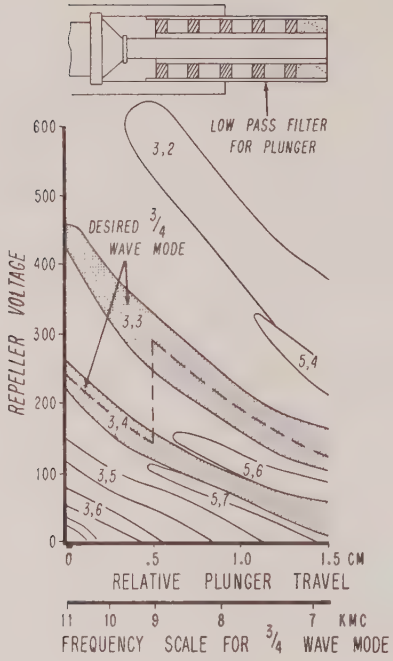


Fig. 3-15 Compensated Mode Structure Showing Mode Shift

RESONATOR

The cavity resonator for the klystron (V114) in the Model 620A is a tunable coaxial line with a shorting plunger. The repeller voltage, plunger, and frequency dial are ganged-tuned which makes the instrument direct reading.

The resonant frequency of a circular coaxial resonator with one end shorted is determined by the electrical length of the resonator in a direction parallel to the center conductor. The other dimensions of the line play small part in defining the fundamental frequency of the section.

The external resonator arrangement while ultimately capable of tuning over a wide band presents design problems concerned with the suppression of undesired oscillations and the accomplishment of mechanical tuning.

UNDESIRED MODE SUPPRESSION

Cavity resonator systems have a natural tendency to operate in the 1/4 wavelength cavity mode, and from the point of view of efficiency, and power output it is advantageous to operate in the 1/4 wavelength cavity mode. As the desired frequency

increases, however, operation on this mode is not always feasible.

As the desired frequency increases, a quarter wavelength becomes quite small, and plunger placement in the cavity becomes extremely critical and imposes mechanical limitations which make it necessary to select another mode for operation. The 3/4 wavelength cavity mode is employed for the range of the Model 620A.

As seen in figure 3-16, the dominant effects of the 1/4 wavelength mode constitutes highly undesirable mode interference. A study of this 1/4 wave cavity and 1-3/4 repeller mode showed that its frequency was everywhere below 6000 megacycles, which is considerably below the 7000 megacycle low end of the Model 620A.

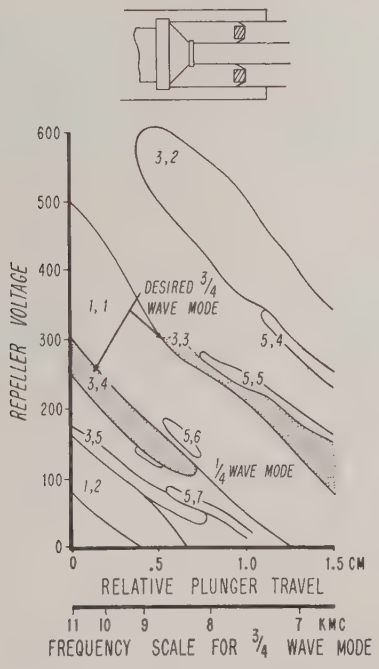


Fig. 3-16 Uncompensated Mode Structure

Advantageous use was made of this fact, and the plunger was designed to incorporate a concentric low-pass filter having a cut-off frequency of 6500 megacycles.

PLUNGER CONSTRUCTION

As seen in Fig. 3-13, the space between the center conductor of the resonant line and the inner wall of the plunger consists of a number of high and low impedance sections in cascade. This constitutes the filter section which is terminated in back of the plunger with powdered iron to absorb the energy passed by the filter.

The effectiveness of this approach to the suppression of the undesired mode is seen in Fig. 3-15. The filter prevents the undesired mode from supporting itself; the first section of the filter appears as a low impedance for the higher frequencies of the desired modes. In effect, the klystron tube is looking at a terminated transmission line at frequencies below 6500 megacycles. For frequencies above 6500 megacycles, the klystron sees a shorted, tunable, high-Q resonator.

The plunger makes contact with the outer conductor wall by means of long life contact fingers. Peripheral resonances are suppressed by loading the gap between the plunger and the outer wall with a dielectric plastic sheath. This technique effectively lowers the frequency of these parasitics to a range much lower than that of the generator, where they are relatively ineffective.

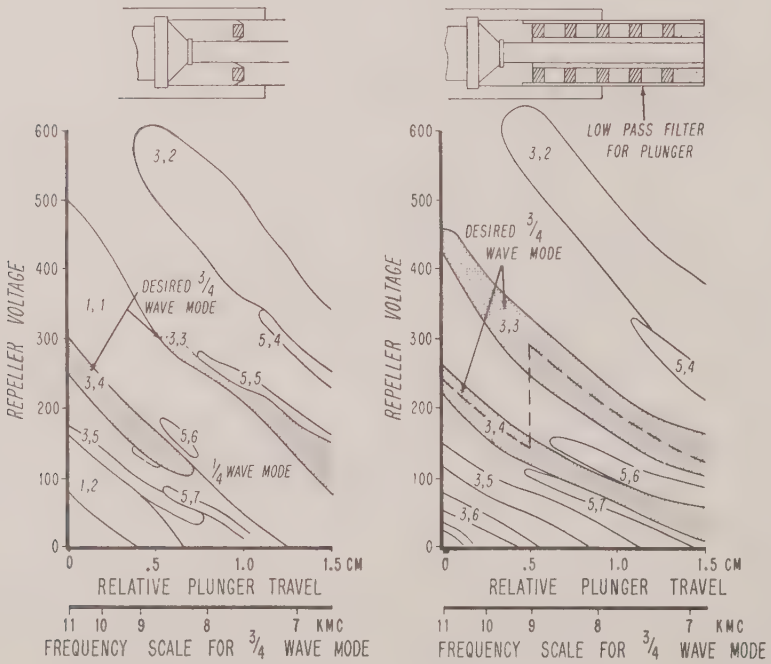


Fig. 3-17 Uncompensated and Compensated Mode Structure

OUTPUT ATTENUATOR

The attenuator in the Model 620A is direct reading and requires no frequency correction. It is essentially a piston probe sliding in a waveguide beyond cut-off.

Theoretically, the high frequencies beyond cut-off involved in such a waveguide demand dimensions which would be smaller than practical. So the dimensions have been increased in favor of practical design. Since the dimensions have been increased, there is a slight error introduced because the frequency vs attenuation characteristic is not sharp at the cut-off frequency.

This error is compensated by distributing it over the frequency and the attenuation ranges of the instrument. This compensation is effected by first halving the error by calibrating the attenuator in the middle of the frequency band (approximately 9 KMC). The half-error now exists at the extremes of the band only.

Second, the power monitor circuit is designed with a gentle rising slope to its calibration against frequency. This means that across the frequency band in the vicinity of -55 dbm, the error is theoretically zero. This has the effect of halving the error again. The overall result is that the error is zero at -55 dbm and rises slightly to less than .5 db at the extreme limits of attenuation and frequency.

The net attenuator-power monitor error is less than the maximum error of the instrument which must allow for connector mismatches and a source impedance which is not quite the ideal 50 ohms resistance which is presented by the pick-up strip on the attenuator probe. See Figure 3-18.

The small dimensions of the waveguide beyond cut-off necessitated careful design of the pick-up loops on the power monitor and attenuator probes. The construction details are shown in Figure 3-19.

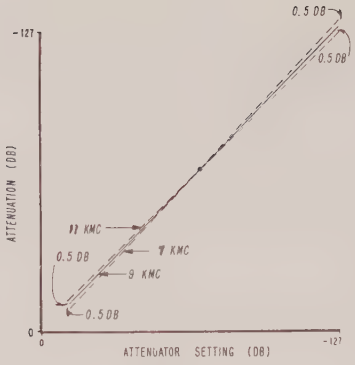


Fig. 3-18 Compensation of Attenuator

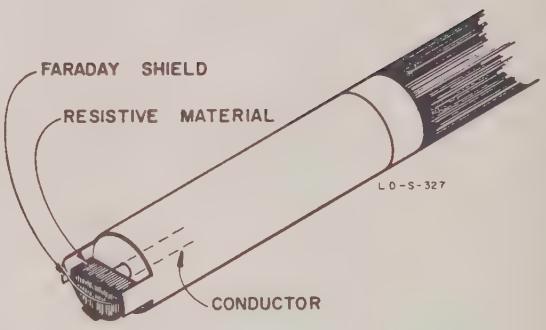


Fig. 3-19 Construction Details of Power Monitor Probe

POWER MONITOR

Since the power generated by the klystron varies with frequency, the power monitor circuit is provided to measure and indicate the level of the field at the attenuator input.

The position drive for the attenuator probe is coupled to the calibrated dial, while the drive for the power monitor is coupled to an index which moves around the outside of the calibrated dial.

The power monitor probe is nearly a duplicate of the attenuator probe, except that the power picked up by the monitor probe is supplied to a coaxial thermistor block mounted on the inside of the front panel.

This thermistor is one arm of the Wheatstone bridge shown in Figure 3-20.

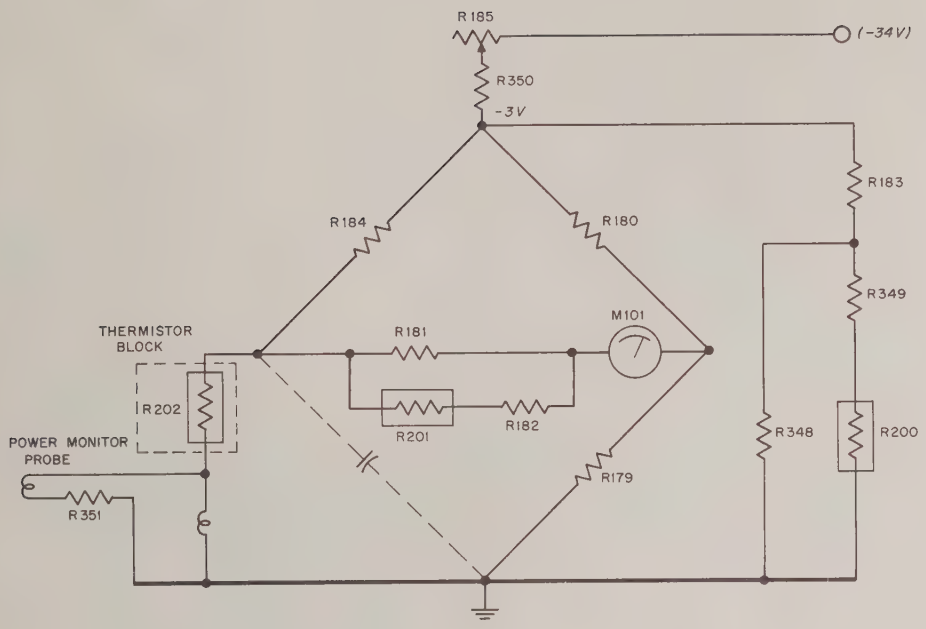


Fig. 3-20 Partial Schematic Showing Thermistor Bridge

The bridge is balanced for dc conditions. When rf power from the monitor probe is applied to the thermistor block, the bridge becomes unbalanced. The 200 microammeter M101 is connected across the bridge to indicate state of balance. R201 is a thermistor in the meter circuit to act as a meter sensitivity regulator to protect the accuracy of the bridge against ambient temperature influences. A second thermistor R200, is shunted across the bridge with a limiting network which compensates for the unbalanced introduced by variations in R202 as influenced by ambient temperature changes.

The position of the monitor probe is controlled by the POWER SET control on the front panel; its position is indicated by the position of the attenuator dial index.

As discussed earlier, the power out of the klystron varies with frequency. For a set frequency, the position of the monitor probe is adjusted so that it picks up enough power to balance the bridge. This establishes the basic reference level.

The calibrated dial indicates decibels below 1 milliwatt when the instrument is loaded with 50 ohms.

DANGER

1000 to 1500 volt potentials from very low impedance sources are used throughout the circuits of the signal generator. Be very careful when handling the generator with the cabinet removed.

NOTE

All operating voltages in the 620A SHF Signal Generator are negative with reference to chassis ground. Therefore, to obtain conventional positive voltage readings at the socket connections, the negative lead of the voltmeter must be placed at the -300 or -1000 volt potentials. It is safer to use a plastic encased voltmeter for such measurements.

SECTION IV

MAINTENANCE

4-1 INTRODUCTORY

This section contains instructions for maintaining, trouble shooting, replacing tubes, and making internal adjustments in the Model 620A SHF Signal Generator. A special systematic trouble shooting procedure tests the complete signal generator in a manner that localizes most troubles which may occur. A chart includes instructions for tube replacement and subsequent adjustments.

Specifications for this instrument appear in the front of this manual. Data contained in the test procedures of Section IV cannot be considered as specifications.

The following information is in this section:

4-2 Cabinet Removal
4-3 Blower System
4-4 Visual Inspection
4-5 Test Equipment Required
4-6 Tube Replacement Chart
4-7 Trouble Localization
4-8 Trouble Shooting the Power Supply Section
4-9 Trouble Shooting the RF Generator Section
4-10 Removing Klystron V114
4-11 Installing Klystron V114
4-12 Adjustments Following Replacement of V114
4-13 Calibrating the Frequency Dial
4-14 Replacing and Calibrating the Attenuator
4-15 Trouble Shooting the Pulser Section
4-16 Calibrating the Pulse Rate Dial
4-17 Calibrating the Pulse Delay Dial
4-18 Calibrating the Pulse Width Dial
4-19 Replacing the Repeller Tracking Potentiometer
4-20 Lubrication
4-21 Replacing RF Power Monitor and Thermistor R202

4-2 CABINET REMOVAL

Remove the 620A cabinet as follows:

a. Place instrument panel down on a low surface so that it rests on the guard rail handles.

b. Loosen the four screws on rear of cabinet, and lift cabinet from chassis.

4-3 BLOWER SYSTEM

Inspect the air filter regularly. If the instrument is operated continuously or in dusty areas, clean the air filter twice a month. Clean air is required for cooling the klystron oscillator inside the cavity, and a clogged filter can shorten the life of the klystron by restricting the air flow. The air filter supplied is a permanent, washable type. You can remove it by simply sliding it from the bracket on the rear of the cabinet. When you clean the filter wash it with soap and water. After rinsing and drying, coat it with a fine spray of light machine oil.

4-4 VISUAL INSPECTION

Always precede electrical trouble shooting with a visual check. Look for signs of damage, burned-out components, etc. Be alert for signs of misuse, looseness of parts, overheating, or any other sign that suggests a source of possible future trouble.

A cold tube found simply by touch may save considerable time and effort in restoring a 620A Signal Generator to operation. A knowledge of the locations of the tubes and sections of the signal generator will assist trouble shooting. Figures 4-4, 4-7, and 4-8 locate the various sections and call out important adjustments, while Figure 4-2 locates the tubes in the instrument.

4-5 TEST EQUIPMENT REQUIRED

The trouble localization procedure described in this section does as much checking as possible using front panel meter indications but requires a reliable and accurate 20,000 ohm/volt multimeter. For a signal tracing and pulse measurements, a high frequency oscilloscope is required. To observe the r-f output pulse waveshape or the repeller modes of the

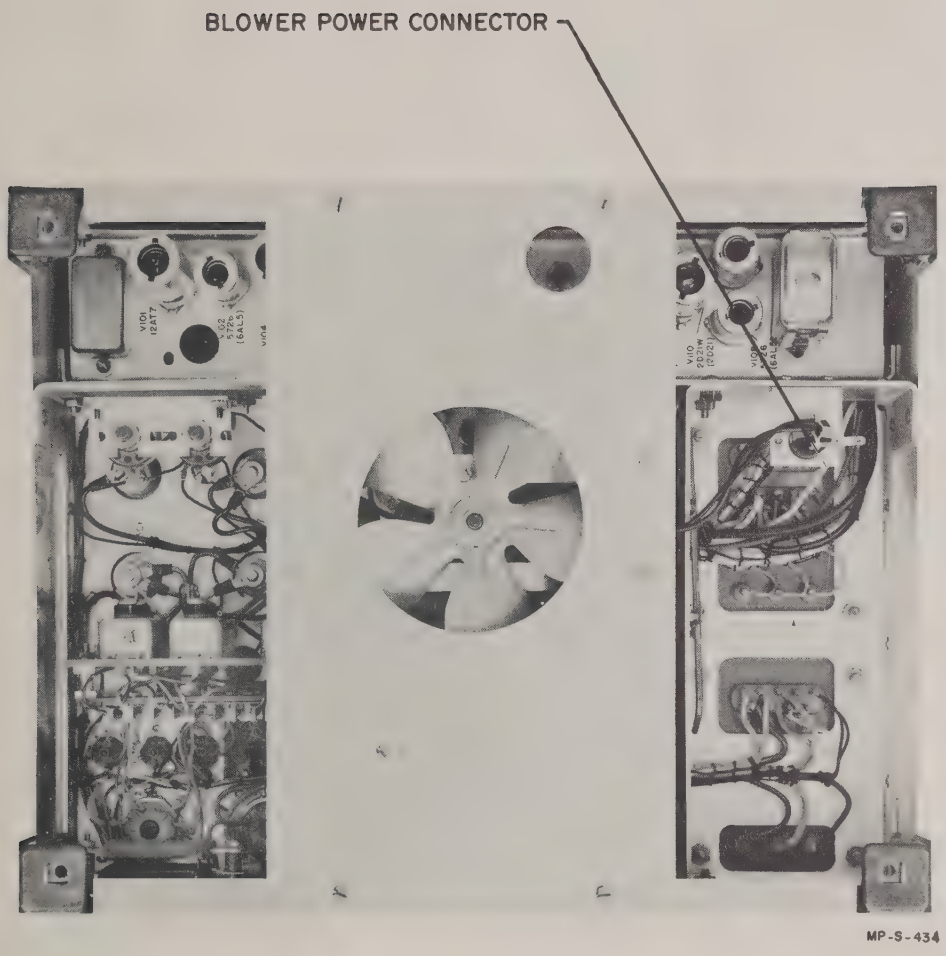


Fig. 4-1 Rear View Showing Blower Connector

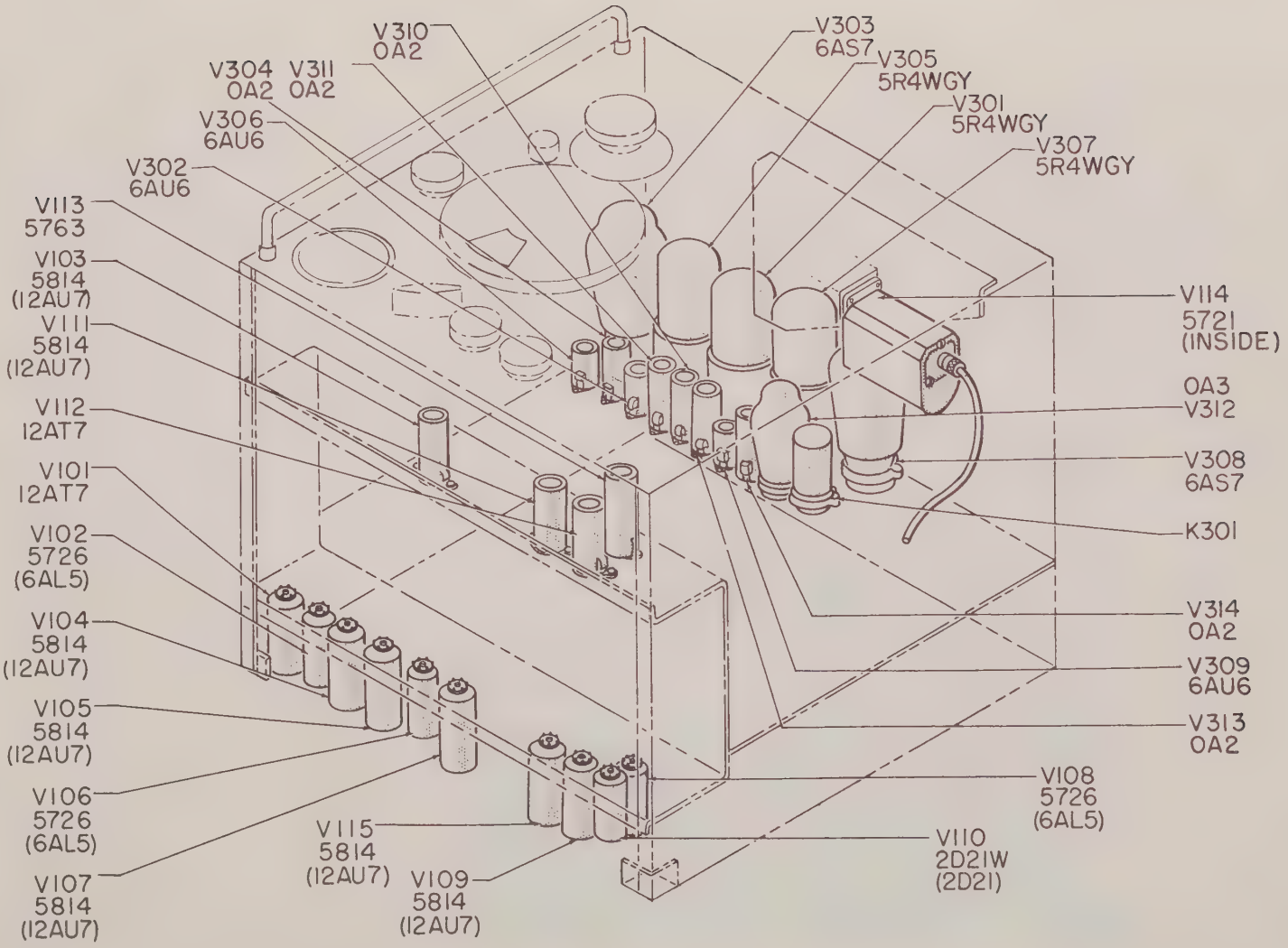


Fig. 4-2 Tube Location Diagram

klystron oscillator, a SHF crystal detector, such as the hp Model 420A, is required ahead of the oscilloscope. To calibrate the power output requires a power meter and bolometer mount, such as the hp Models 430C and H485B, respectively. The H485B Detector Mount is a waveguide device and must be coupled to the front panel type N output jack through a waveguide-to-coax adapter, such as the hp Model H281A.

Table 4-1. Test Equipment Required

NAME	CHARACTERISTIC	APPLICATION
Multimeter (such as Simpson 260, Triplett 630-A).	DC - AC - OHMS 20,000 ohms per volt.	General testing and trouble shooting.
Oscilloscope (such as hp 150A or 160B)	.05 volt/cm sensitivity, 1 μsec sweep, 10 mc frequency response.	Waveform and klystron repeller mode observation.
Crystal Detector (hp Model 420A).		RF Output pulse observation.
Power Meter (hp Model 430C) and Tunable Bolometer Mount (hp Model H485B) and Waveguide to Coax Adapter (hp Model H281A).		RF power output measurement.

4-6 TUBE REPLACEMENT

The tubes used in the 620A Signal Generator are listed in the following table. Many of the tubes may be replaced without further adjustment; those which require adjustment when replaced are accompanied by a reference to the pertinent step in the trouble shooting chart, Table 4-4. It is recommended that tubes be checked by substituting a new tube of the same type; if no improvement in performance is noted, return the original tube to the socket.

Table 4-2 Tube Complement, Signal Generator 620A

Tube	Type	Function	Adjustments Required
V101	12AT7	Sync Amplifier and Inverter	None
V102	6AL5	Clipper (1/2 tube not used)	None
V103	12AU7	Rate Multivibrator	Para. 4-16
V104	12AU7	Pulse Shaping Multivibrator	None
V105	12AU7	Pulse Amplifier and Sync Out Cathode Follower	None
V106	6AL5	Base Limiter for Delay Multivibrator	None
V107	12AU7	Delay Multivibrator	Para. 4-17
V108	6AL5	Blocking Diode	None
V109	12AU7	Pulse Amplifier Inverter and Delayed Sync Out Cathode Follower	None
V110	2D21	Thyratron Discharge Tube	None
V111	12AU7	Pulse Width Multivibrator	Para. 4-18
V112	12AT7	Clipper and Klystron Bias Regulator	Steps 7 & 8*
V113	5763	Modulator	Steps 7 & 8*
V114	5721	Radio Frequency Oscillator	Para. 4-10, 4-11, and 4-12
V115	12AU7	Delayed Sync Out	None
V301	5R4GY	Full Wave Rectifier	None
V302	6AU6	Regulator Amplifier	Step 1*
V303	6AS7	Series Regulator	Steps 1 & 2*
V304	OA2	Voltage Regulator	Step 1*

* The steps referred to in this table appear in table 4-4.

Tube	Type	Function	Adjustments Required
V305	5R4GY	Full Wave Rectifier	None
V306	6AU6	Regulator Amplifier	Step 2*
V307	5R4GY	Full Wave Rectifier	None
V308	6AS7	Series Regulator	Step 4*
V309	6AU6	Regulator Amplifier	Step 4*
V310	OA2	Voltage Regulator	Step 4*
V311	OA2	Voltage Regulator	Step 4*
V312	OA3	Voltage Regulator	Steps 4 & 5*
V313	OA2	Voltage Regulator	Step 6*
V314	OA2	Voltage Regulator	Step 6*

* The steps referred to in this table appear in table 4-4.

4-7 TROUBLE LOCALIZATION

The Model 620A SHF Signal Generator is a precision instrument conservatively designed for long component life. It is not expected that components such as resistors, capacitors, chokes and transformers will present service problems and that tube replacement and adjustments will repair a majority of troubles that may develop.

The first step in correcting any trouble which may occur in the signal generator is the isolation of the section causing trouble. The circuits of the 620A Signal Generator occupy easily defined areas and offer very good circuit accessibility. The location of these sections is shown in Figures 4-4, 4-7 and 4-8. Figures 4-1 and 4-11 may also prove helpful in locating circuits within the instrument.

Trouble ordinarily occurs in only one section of an equipment at one time; therefore, it is usually necessary to correct only the one trouble. Isolation of a circuit failure is best accomplished by considering the basic sections shown in the block diagrams in Figures 4-5 and 4-6. The diagrams in Figure 4-5 show the sections of the generator that are operated by each front panel control; the block diagram in Figure 4-6 shows expected waveforms at important points throughout the circuit.

Careful determination of the nature of a trouble symptom will usually lead to the section at fault. The following systematic trouble chart lists various tests with symptoms of trouble, possible causes, and remedies. Perform the steps in the order given. For simplification, only tubes are referred to in the trouble shooting chart, and it should be remembered that components associated with the referenced tube are also failure possibilities. The power supply is checked first, then the rf power monitor, the rf oscillator, and last the pulser section. For all testing of the 620A Signal Generator, the use of a variable transformer to adjust the line voltage between 103 and 127 volts is recommended. An instrument in good electrical condition should operate satisfactorily over this voltage range. An instrument having marginal operation (from weak tubes, etc.) can be quickly detected by reducing the line voltage to 103 volts. At this point, the various weaknesses are amplified and become easier to trace.

4-8 TROUBLE SHOOTING THE POWER SUPPLY SECTION

Correct operation of the power supply is vital to proper operation of the 620A Signal Generator. Noise or variation in the regulated voltages causes other circuits to operate in a random or erratic manner. It is advisable to make a resistance and voltage check on the power supply whenever the 620A is suspected of marginal operation and prior to any service work. This will eliminate such factors as low voltages or poor regulation as causes of unsatisfactory performance.

The power supply section of the 620A contains three regulated power supplies as shown in block diagram Figure 4-3. The 300 volt and the 1000 volt supplies both have their positive terminals grounded to the chassis which means that their output voltages are negative with respect to the chassis. The 500 volt supply is connected to the output of the 1000 volt supply so that the output voltages from the 500 volt supply are algebraically added to the 1000 volt supply.

The 300 volt supply is independent of the other two supplies and delivers -300 volts for operation of the modulator section of the 620A. The -300 dc regulated voltage is used as a reference voltage for the regulator in the 1000 volt supply. Any changes in the 300 volt supply output will be reflected in the 1000 volt supply.

The 500 volt supply has output voltages of +75, -200, and -500 with respect to a common point within the supply. This common point is connected to the -1000 volt output from the 1000 volt supply to provide voltages of -925, -1200, and -1500 dc volts.

When the instrument is turned on, a thermal time delay relay turns the 1000 and 500 volt supplies on after a 30 second delay.

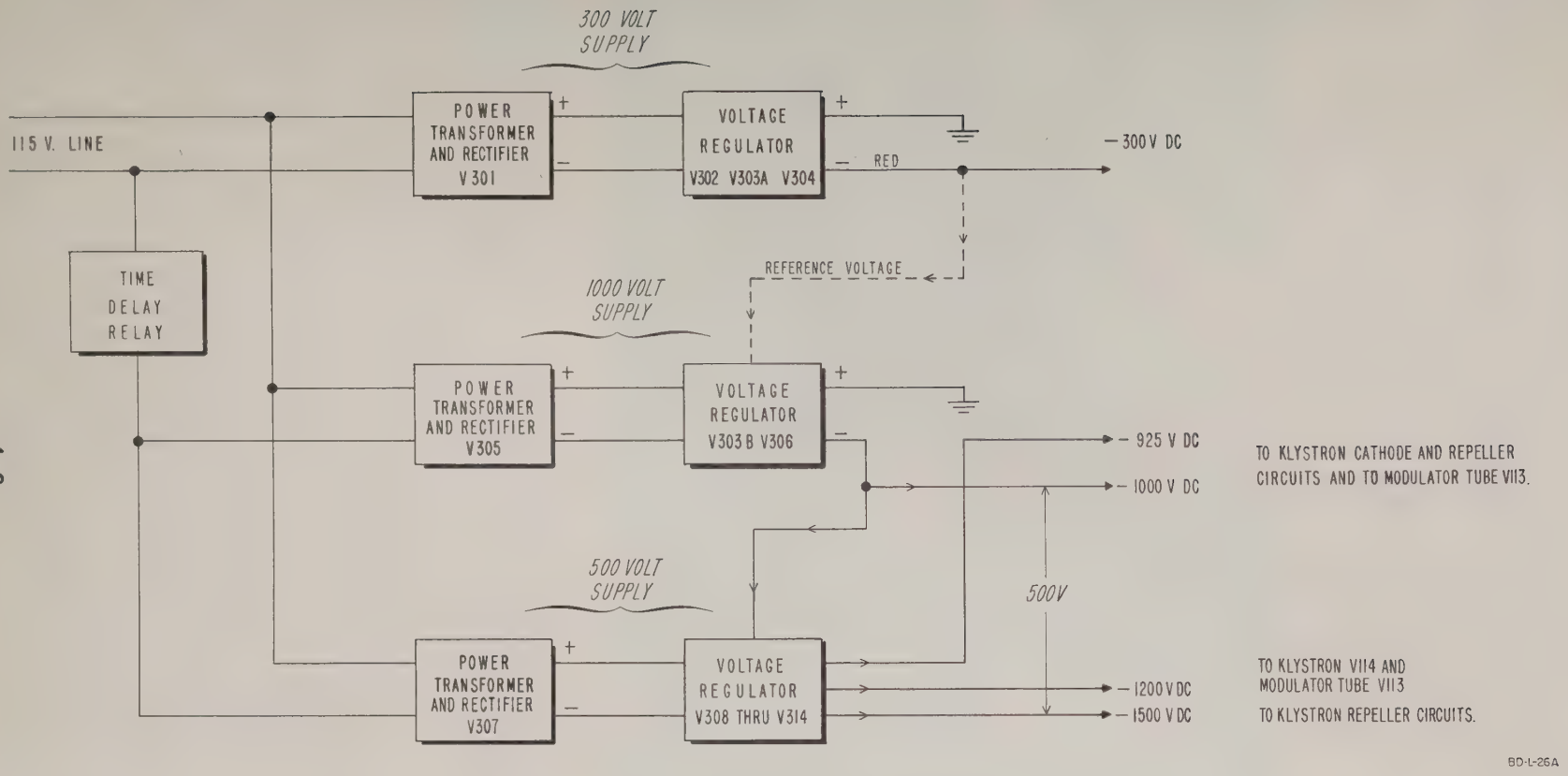
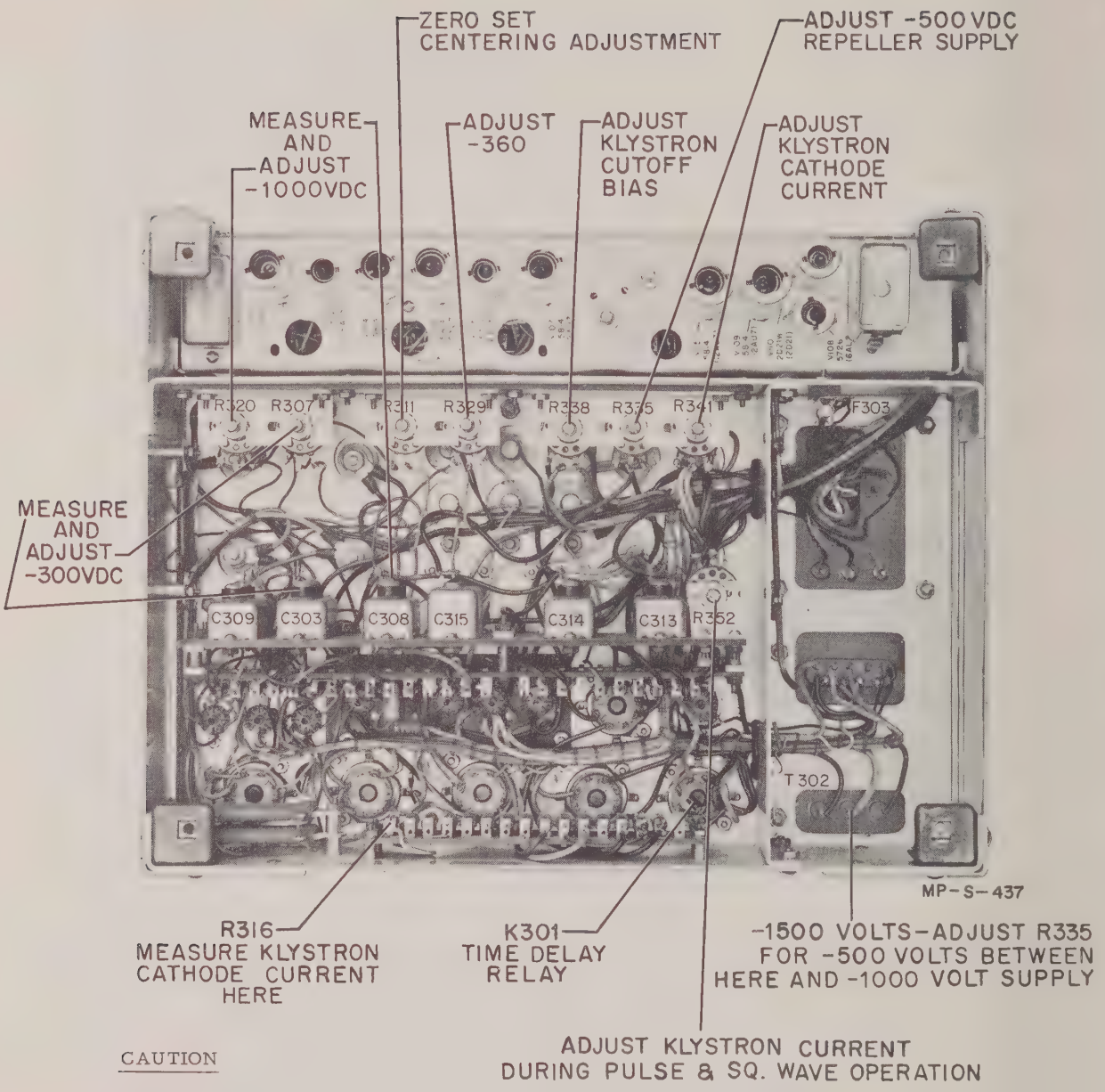


Fig. 4-3 Block Diagram of Power Supply



CAUTION

When making electrical adjustments shown in this rear view which are accessible only through the blower blades, disconnect blower by removing plug adjacent to power transformer and blower support. Leave blower disconnected no longer than necessary.

Fig. 4-4 Rear View Showing Power Supply Section, Blower Removed for Clarity

To check the power supply, measure the voltages and resistances at the rear of the instrument with the cabinet removed (see Figure 4-4, Power Supply Deck). Table 4-3 lists the proper voltage and resistance values that may be read at the points called out in Figure 4-4. Make all measurements with a 20,000 ohm/volt multimeter.

Table 4-3 Power Supply Test Measurements

Power Supply Voltage	Current (MA) Off	CW	Resistance
-300v to ground	83	83	10,000 ohms to ground
-1000v to ground	4.8	25	200,000 ohms to ground
-1200v to ground (-200 v to -1000v supply)	5.7	33	28,000 ohms to -1000 volt bus
-1500v to ground (-500 to -1000v supply)	35	58	135,000 ohms to -1000 volt bus.

Adjust the voltage applied to the instrument between103 and 127 volts while measuring the output voltage of the regulated supply in question. The regulated voltages may vary ± 3% with a line voltage change from 103 to 127 volts. Hum level should be less than 30 millivolts with the same line voltage variation.

The MOD SELECTOR should be in the OFF position when making Table 4-4 measurements unless otherwise specified.

4-9 CHECKING AND TROUBLE SHOOTING THE RF GENERATOR SECTION

Satisfactory voltages obtained in the power supply trouble shooting chart assure that with the exception of the klystron repeller voltages, the proper operating voltages are applied to all portions of the signal generator. The 620A can generate a CW output signal with a minimum of circuits operating. The output meter monitors the klystron itself directly and if known to be operating properly may be used to check operation of the klystron oscillator. Steps 9 and 10 of table 4-4 list steps to determine if the r-f power monitor and r-f generator are operating; and, if not, where the trouble lies.

Table 4-4. Power Supply Trouble Shooting and Tube Replacement Procedure

CHECK AND SYMPTOM	POSSIBLE CAUSE	REMEDY
1. Check the -300-volt supply. Measure voltage between instrument chassis and the top terminal of C303 (small red lead).		
Small deviation:	Out of adjustment.	Adjust R307 to obtain 300 volts; check all regulated voltages.
Low voltage:	Defective rectifier V301 or regulator V303.	Replace V301 and/or V303. Adjust R307 as above.
	Excessive loading.	Check resistance of and current through load. (See list above.)
High voltage:	Defective control tube V302.	Replace V302. Adjust R307 as above.
Erratic, unstable voltage:	Defective reference tube V304.	Replace V304. Adjust R307 as above.
2. Check the -1000-volt supply. Measure voltage between instrument chassis and the top terminal of C308 (large red lead).		
Small deviation:	Out of adjustment.	Adjust R320; check all regulated voltages.
No voltage:	Defective relay K301.	Replace K301; check time delay.
	Burned out resistor R316.	Replace R316 and locate reason for burnout.
Low voltage:	Defective rectifier V305 or regulator V303.	Replace V305 and/or V303. Adjust R320 as above.
High voltage:	Defective control tube V306.	Replace V306. Adjust R320 as above.
3. Check -360-volt pulser bias. Measure the voltage between the center arm of potentiometer R329 and chassis.		
Incorrect voltage:	Out of adjustment.	Adjust R329 to obtain -360 volts.
	Excessive loading.	Check pulser for short.

4. Check the -500 volt klystron repeller supply. See Figure 4-4.		
Small deviation:	Out of adjustment.	Adjust R335 to obtain -500 volts.
Low voltage:	Defective rectifier V307 or regulator V308 or shorted capacitor C314.	Replace V307 and/or V308; adjust R333 as above.
High voltage:	Defective control tube V309.	Replace V309; adjust R333 as above.
Erratic, unstable voltage:	Defective reference tubes V310, V311, and V312.	Replace V310, V311, V312; adjust R333 as above.
5. Check regulator V312 with the MOD. SELECTOR in OFF and CW positions. Measure voltage between the center and top terminals of C308 (large red and brown leads). CW = approximately 73 volts; OFF = approximately 75 volts.		
Unstable or incorrect voltage:	Defective V312.	Replace V312. No adjustment required.
	Incorrect setting of klystron off-bias adjustment R338.	Reset R338 as described in Step 8.
6. Check regulators V313 and V314 with the MOD. SELECTOR in the OFF and CW positions. Measure voltage between center and top terminals of C314 (large black and pink leads). Voltage should remain at 300 volts.		
Unstable or incorrect voltage:	Defective V313 or V314. Incorrect setting of klystron off-bias adjustment.	Replace V313 or V314; readjust R338, klystron off-bias as described in Step 8.
	Excessive loading.	Check for shorts.

Table 4-4. (Continued)

CHECK AND SYMPTOM	POSSIBLE CAUSE	REMEDY
7. Check the klystron cathode current. Measure the d-c voltage across R316 (see Figure 4-4) with the MOD. SELECTOR in the ON position. Voltage should be between 2.0 and 2.5 volts.		
Voltage too high or too low:	Out of adjustment.	Adjust R341 to obtain from 2.0 to 2.5 volts for optimum overall operation (CW and Pulse) of the klystron.
Cannot increase this voltage by adjustment of R341:	Weak klystron V114.	Replace V114, as described in paragraphs 4-10, 4-11 and 4-12.
8. Check the klystron off-bias. Connect the d-c voltmeter between the top terminal of C308 and the junction of R164 and R165. Voltmeter should read from -22 to -25 volts with the MOD. SELECTOR in the OFF position.		
Voltage too low or too high:	Out of adjustment.	Adjust R338 to obtain -22 volts or slightly more if required to cutoff the klystron. When the klystron is cutoff, the voltage across R316 drops to approximately .1 volt.
Cannot increase this voltage by adjustment of R338:	Weak modulator V113.	Replace V113 and readjust R338.

9. Note output meter indications with MOD. SELECTOR at OFF.		
Meter inoperative; no zero set:	No supply voltage Fuse F303 blown.	Measure supply voltage at R185; should be approximately -3 volts from ground. Replace F303 and determine cause for burn-out.
	Open meter M101.	Disconnect meter and check continuity. Caution! 200 μamp movement
Meter pins upscale or downscale:	Shorted or open component on one or other side of bridge to cause unbalance.	Disconnect one side of meter. Measure supply voltage at R185; should be approximately -3 volts from ground. Then measure the voltage between each side of the bridge to determine side at fault. The voltage at both midpoints on each side of the bridge should be 1/2 the voltage applied to the bridge from ZERO SET potentiometer R185.
Meter erratic under all conditions:	Unstable thermistor R202.	Replace entire thermistor block assembly and recalibrate the attenuator as described in Para. 4-14.
Meter erratic during CW operation only, also very poor frequency response:	Open power monitor pickup resistor R351.	Check resistance by disconnecting cable and measuring R351. Resistance should be between 50 and 125 ohms.
Meter indicates r-f power output with the MOD. SELECTOR in the OFF position:	Defective modulator tube V113.	Replace V113 and reset klystron operating bias as described in step 7.
10. Reading the front panel output meter, check CW operation of klystron over the full frequency range.		
CW output weak or spotty:	Unstable klystron operation, particularly at high frequency end of range due to poor klystron seating in cavity or improper repeller supply voltage settings, insufficient beam current or weak klystron.	Check setting of repeller voltage as described in paragraph 4-12. If voltages cannot be improved check seating, tighten seating nut, or, loosen nut and carefully turn tube 1/8 turn and retighten nut. Recheck. Remove tube and clean up seat. Using care not to scratch glass, clean klystron grid rings. Check beam current as in step 7.
Poor pulse output, CW output Satisfactory:	R352 out of adjustment.	Adjust R352 for best pulse operation.

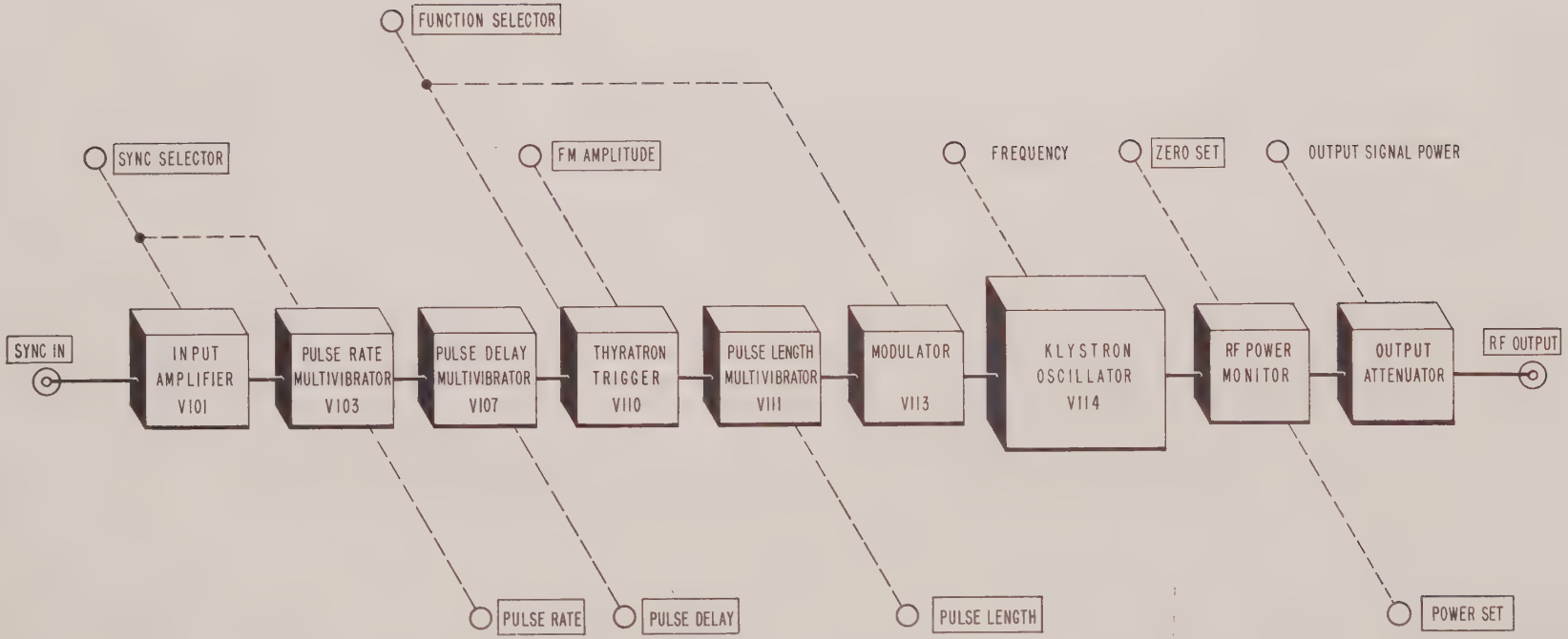


Fig. 4-5 Block Diagram Showing Major Circuits as Operated by Panel Controls

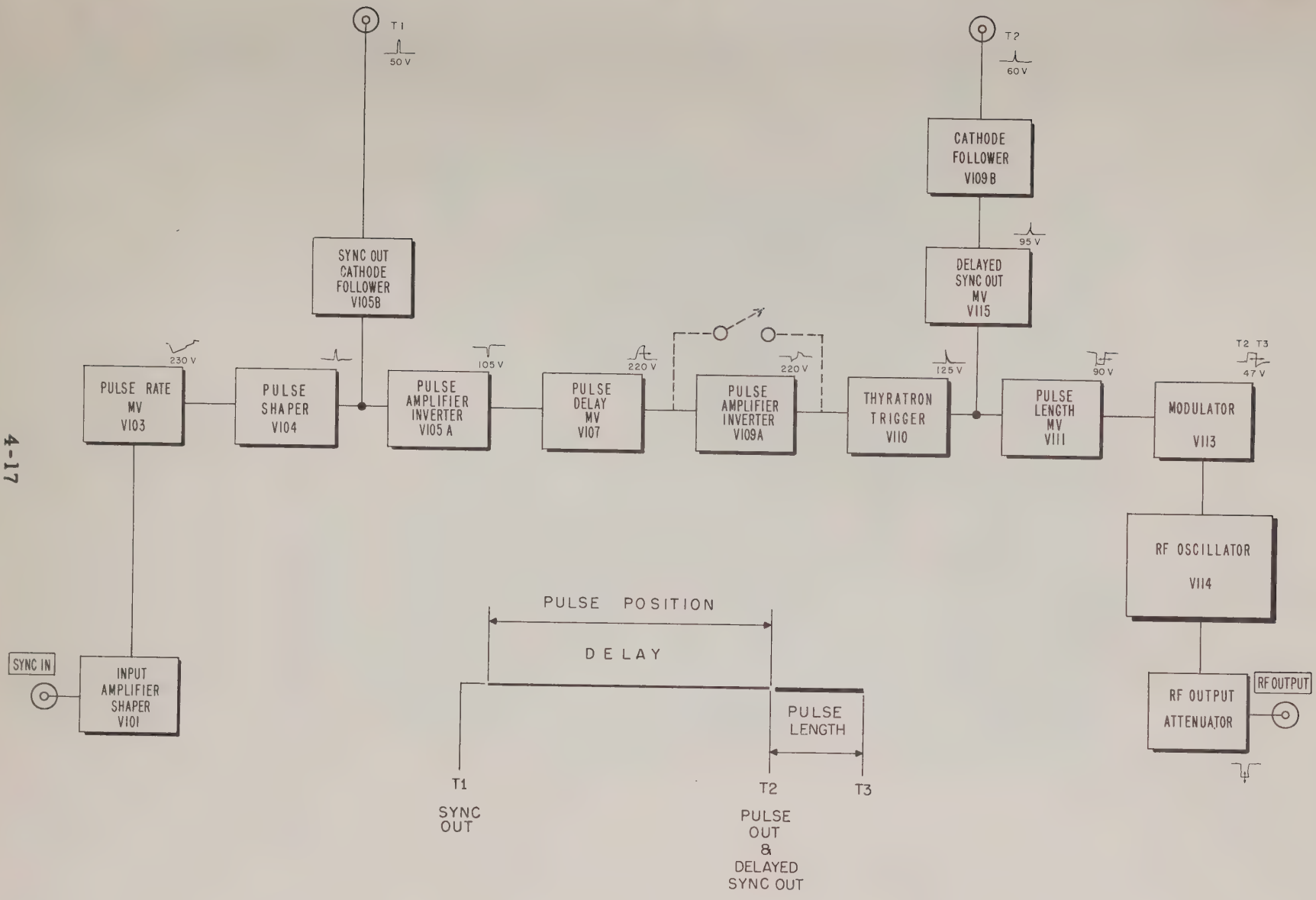


Fig. 4-6 Block Diagram Showing Important Waveforms

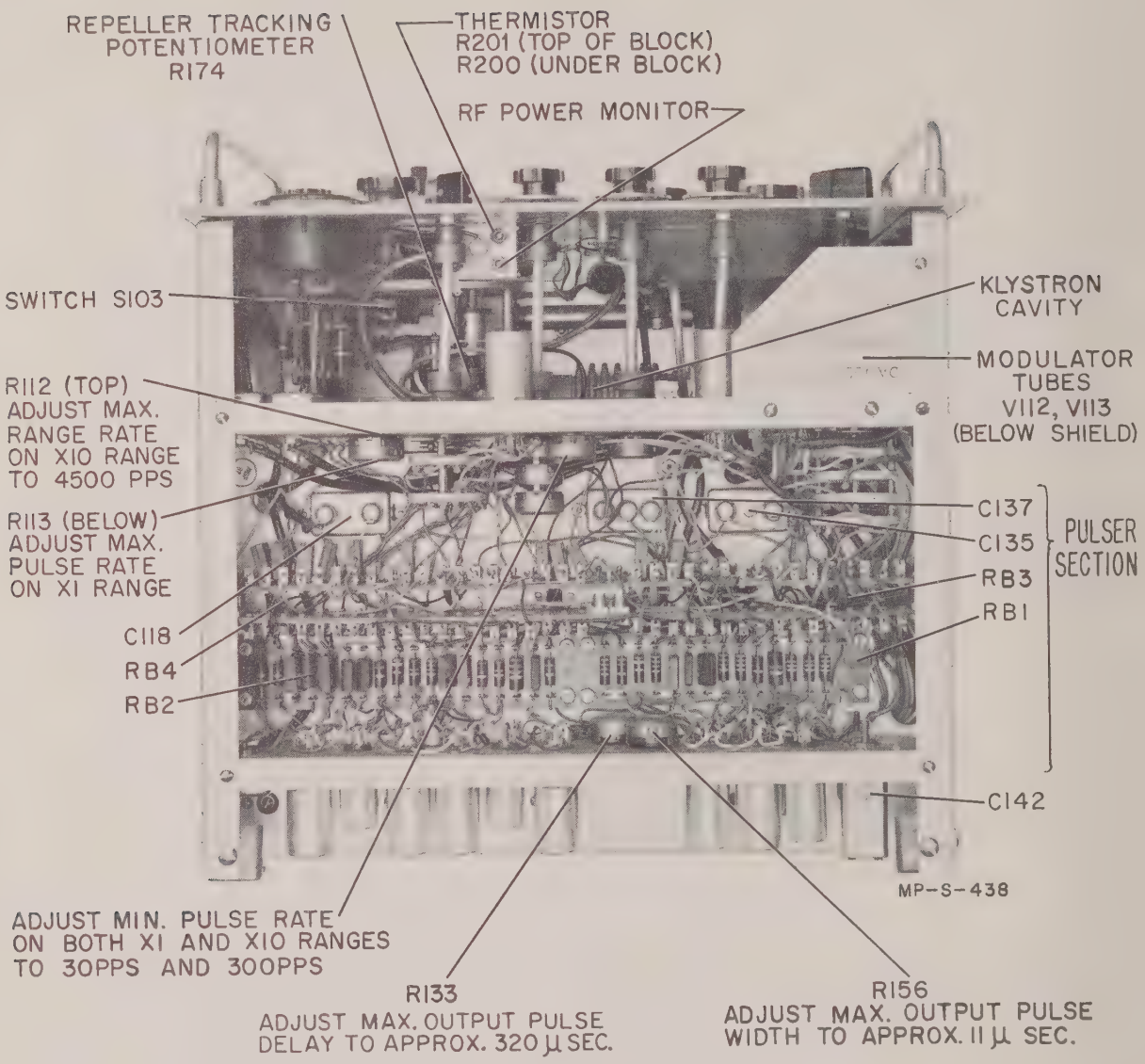

REPELLER TRACKING POTENTIOMETER R174
THERMISTOR R201 (TOP OF BLOCK) R200 (UNDER BLOCK)
RF POWER MONITOR
SWITCH S103
KLYSTRON CAVITY
MODULATOR TUBES V112, V113 (BELOW SHIELD)
R112 (TOP) ADJUST MAX. RANGE RATE ON X10 RANGE TO 4500 PPS
R113 (BELOW) ADJUST MAX. PULSE RATE ON X1 RANGE
C137
C135
PULSER SECTION
RB3
RB1
C118
RB4
RB2
C142
MP-S-438
ADJUST MIN. PULSE RATE ON BOTH X1 AND X10 RANGES TO 30PPS AND 300PPS
R133
ADJUST MAX. OUTPUT PULSE DELAY TO APPROX. 320 μ SEC.
R156
ADJUST MAX. OUTPUT PULSE WIDTH TO APPROX. 11 μ SEC.

Fig. 4-7 Top View Showing RF Power Monitor

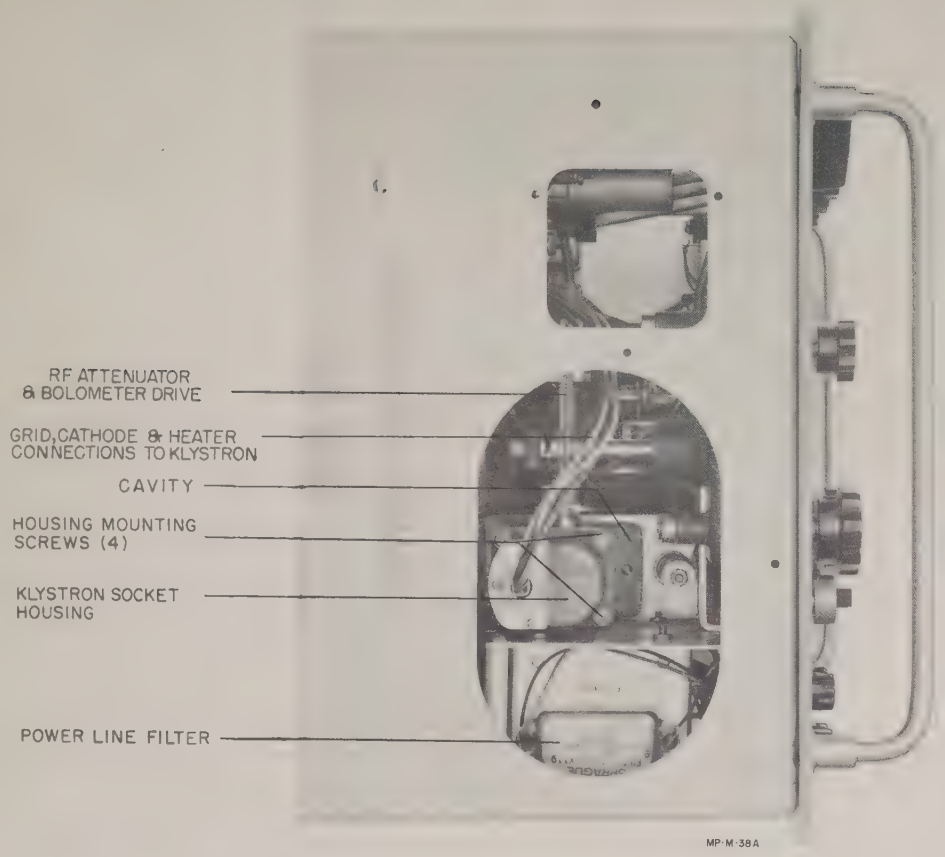


Fig. 4-8 Left Side Showing Klystron Removal

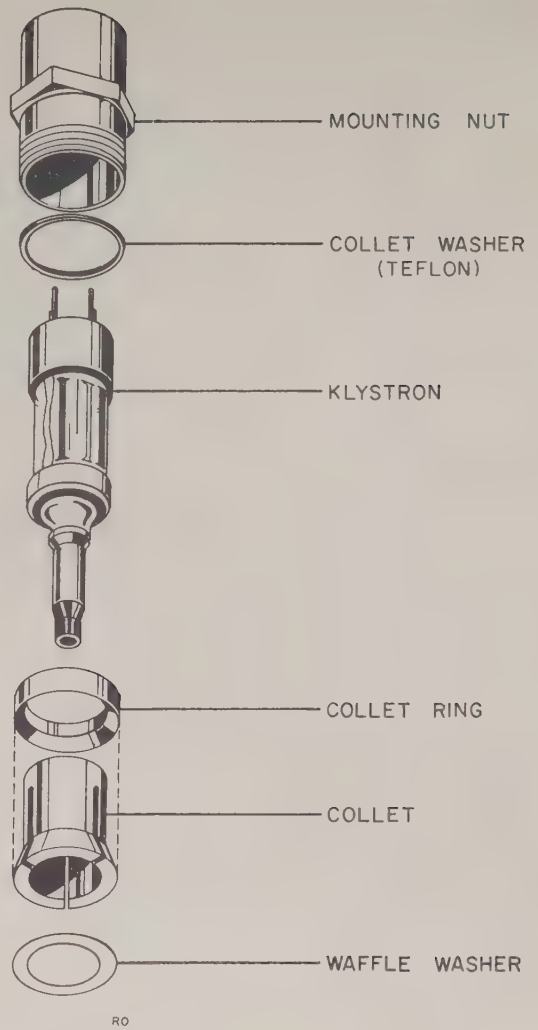


Fig. 4-9 Exploded View of Klystron Mounting Parts

4-10 KLYSTRON REMOVAL

To remove the klystron oscillator tube V114 from the resonant cavity, remove the instrument from the cabinet as described in Paragraph 4-2. The klystron is located at the left side of the instrument just behind the front panel. (See Figure 4-8) refer to Figure 4-9 and proceed as follows:

CAUTION

Do not at any time apply side motion to the Klystron. To do so will break the tube.

a. Remove the four Allen screws from the Klystron tube base cover. An Allen wrench is furnished with the instrument and is located at the left rear corner of chassis on clip marked H-304.

b. Pull tube base cover straight to expose the tube base.

c. Remove socket from klystron. Pull socket straight off of klystron to avoid breaking the klystron.

d. Loosen and remove klystron mounting nut with wrench supplied.

e. Remove collet washer with a sharp tool. Grasp klystron tube base and pull straight out of cavity. Collet and collet ring should be removed by hand if still in cavity.

f. If collet ring and collet are locked on klystron, place klystron on its base and gently tap collet ring to free the collet.

NOTE

See Klystron Tube Warranty Claim and Replacement Procedure at rear of Table of Replaceable Parts.

4-11 KLYSTRON REPLACEMENT

a. Insert waffle washer in cavity. Use new washer if old washer is damaged.

b. Place collet ring on collet, making sure taper on ring seats against flare of collet.

c. Place collet washer over collet. Place mounting nut over collet washer.

d. Place klystron into collet with 4 pin base opposite the flare of collet.

e. Insert klystron assembly into cavity and tighten mounting nut by hand until collet just grips klystron, but klystron should still be free to rotate.

f. Slide klystron out approximately 1/8 inch, then push in until klystron seats firmly against shoulder in collet. DO NOT USE EXCESSIVE PRESSURE to prevent possible damage to klystron.

g. Tighten mounting nut by hand, then push socket on klystron base, being careful not to exert any side pressure on the klystron.

h. Remove cover plate from frequency drive mechanism to check repeller cable. Be sure to push the repeller cable into center conductor to connect the repeller before turning on the instrument. FAILURE TO MAKE REPELLER CONNECTION may cause damage to klystron.

i. Complete klystron adjustment given in step a through r of Paragraph 4-12.

4-12 ADJUSTMENTS FOLLOWING REPLACEMENT OF KLYSTRON V114

Following replacement of V114, it is important that certain adjustments be made as soon as the signal generator is turned on. The following procedure is recommended. Step references are steps included in trouble shooting chart.

a. With signal generator removed from the cabinet, set MOD SELECTOR to OFF, and turn on instrument.

b. Check -1000 volts supply, -500 volts supply, and klystron cutoff bias. Refer to Table 4-4 for adjustments.

c. Set frequency dial on 10 kmc.

d. Set MOD SELECTOR to CW and adjust klystron beam current with R341 to approximately 22 ma (2.2 volts across R316).

e. Adjust POWER SET control to obtain up-scale indication on the power set meter. If necessary, adjust R170 to obtain meter indication. Recheck klystron beam current (25 ma maximum in cw operation).

f. Tune signal generator to the frequency just above the point where the microswitch is actuated (approximately 8.8 kmc).

g. Connect equipment as follows:

(1) Crystal detector, such as hp Model 420A, to RF OUTPUT connector.

(2) Output of crystal detector to vertical input terminals of an oscilloscope.

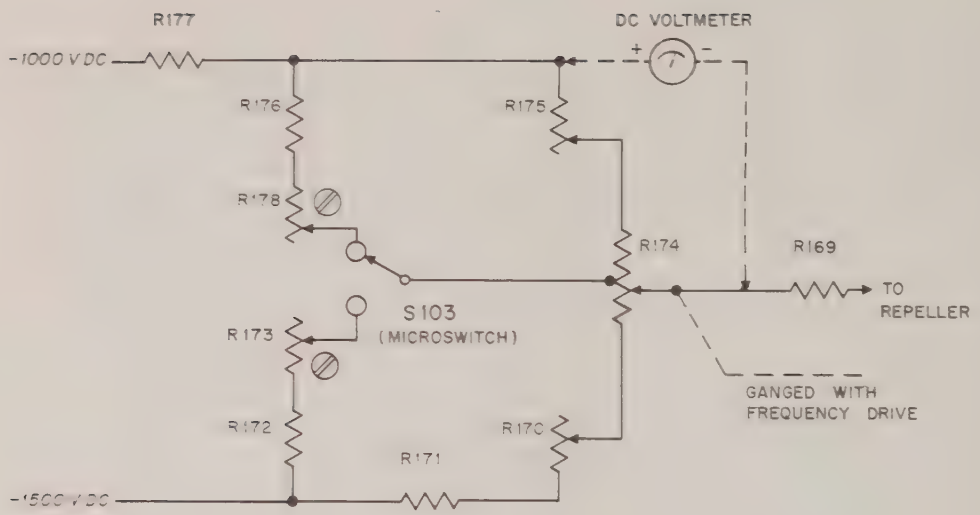


Figure 4-10. Partial Schematic Showing Klystron Repeller Tracking Circuits

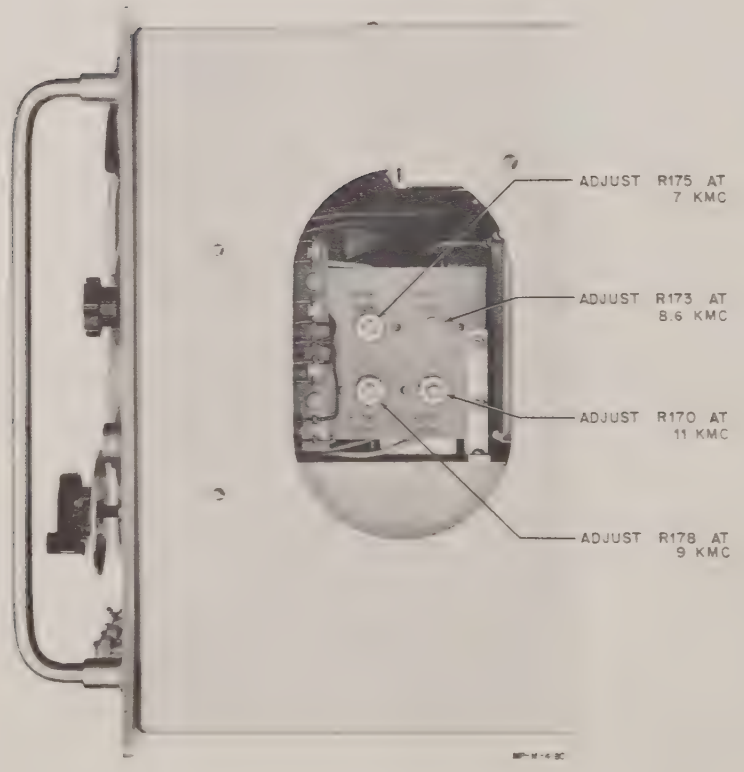


Figure 4-11. Right Side View Showing Repeller Voltage Adjustments

(3) External modulating voltage to EXT MOD connector and horizontal input terminals of an oscilloscope.

h. Set MOD SELECTOR to EXT FM and observe the repeller mode pattern on an oscilloscope. Adjust OUTPUT ATTEN to obtain the desired vertical deflection on an oscilloscope. Adjust FM AMPLITUDE control to obtain humped waveform as shown in figure 4-12. If necessary, adjust the phase of repeller mode pattern.

i. Tune signal generator across the band while observing the repeller mode pattern on an oscilloscope. If the rf power level drops abruptly (in general, between 8.4 and 8.7 kmc) proceed as follows:

(1) Turn off instrument.

(2) Loosen klystron mounting nut.

(3) Rotate klystron slightly and make sure klystron is seated properly against shoulder in collet.

(4) Tighten klystron mounting nut by hand.

(5) Check to be sure that the repeller cable is not twisted and makes firm connection to repeller.

(6) Turn on instrument and observe repeller mode patterns on an oscilloscope.

Repeat steps 1 through 6 (above) by rotating klystron slightly each time until the optimum repeller mode pattern is obtained across the band.

j. Turn off instrument. Set frequency dial at high frequency stop and tighten klystron mounting nut with wrench supplied.

k. Install tube socket housing with cable entrance towards rear of instrument. Replace four Allen screws.

l. Disconnect crystal detector from RF OUTPUT connector.

m. Connect equipment as follows:

(1) Wavemeter, such as Ⓗ Model X532A with Model X281A Waveguide-to-Coax Adapter and Model X421A Crystal Detector, to RF OUTPUT connector.

(2) Output of crystal detector to vertical input terminals of an oscilloscope.

n. Turn on instrument.

o. Measure the frequency with the wavemeter. If the measured frequency is below 11.1 kmc, remove the bottom plate from the frequency drive mechanism and proceed as follows:

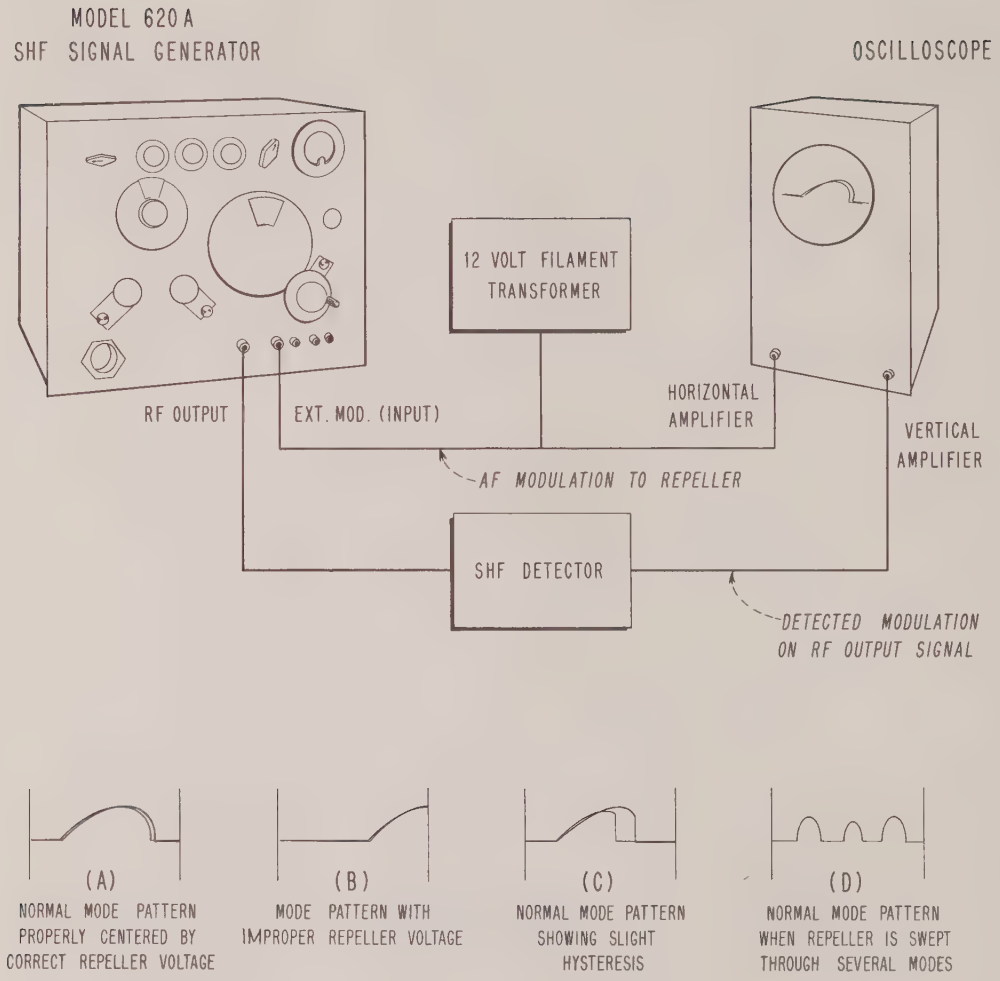


Figure 4-12. Test Setup for Observing Repeller Modes

(1) Loosen plunger cap screw (Figure 4-13).

(2) Set wavemeter on 11.1 kmc.

(3) Gently tap rear of plunger until wavemeter dip is centered on the mode pattern.

(4) Tighten plunger cap screw and replace bottom plate.

If the measured frequency is above 11.1 kmc, remove the bottom plate from the frequency drive mechanism and proceed as follows:

(1) Set wavemeter on 11.1 kmc.

(2) Turn frequency dial until wavemeter pattern is centered on the mode pattern.

(3) Loosen plunger cap screw.

(4) Turn frequency dial to high frequency stop while plunger remains stationary.

(5) Tighten plunger cap screw and replace bottom plate.

p. Tune signal generator across the band and center the repeller mode pattern with repeller tracking controls (R170, R173, R175 and R178). Figure 4-12 "a" and "c" show two typical mode patterns. The "a" shows a symmetrical mode pattern that is properly centered by the correct repeller voltage; the "b" shows the same pattern set off center by incorrect setting of repeller voltage. Adjust R170 and R178 to obtain correct repeller voltage tracking between 11 kmc and the frequency just above the point where the microswitch is actuated (approximately 8.7 to 9 kmc). Adjust R173 and R175 to obtain correct repeller voltage tracking between the frequency just below the point where the microswitch is actuated (approximately 8.6 kmc) and 7 kmc.

q. Check signal generator output using square wave and pulse operations over the entire frequency band. If the shape of waveform deteriorates readjust the appropriate repeller tracking control at the frequency where instability appears.

r. Recheck the entire frequency band and make any minor refinements which may be necessary for best overall operation, i.e., stable CW, square-wave and pulse operation with specified power output over the full frequency range.

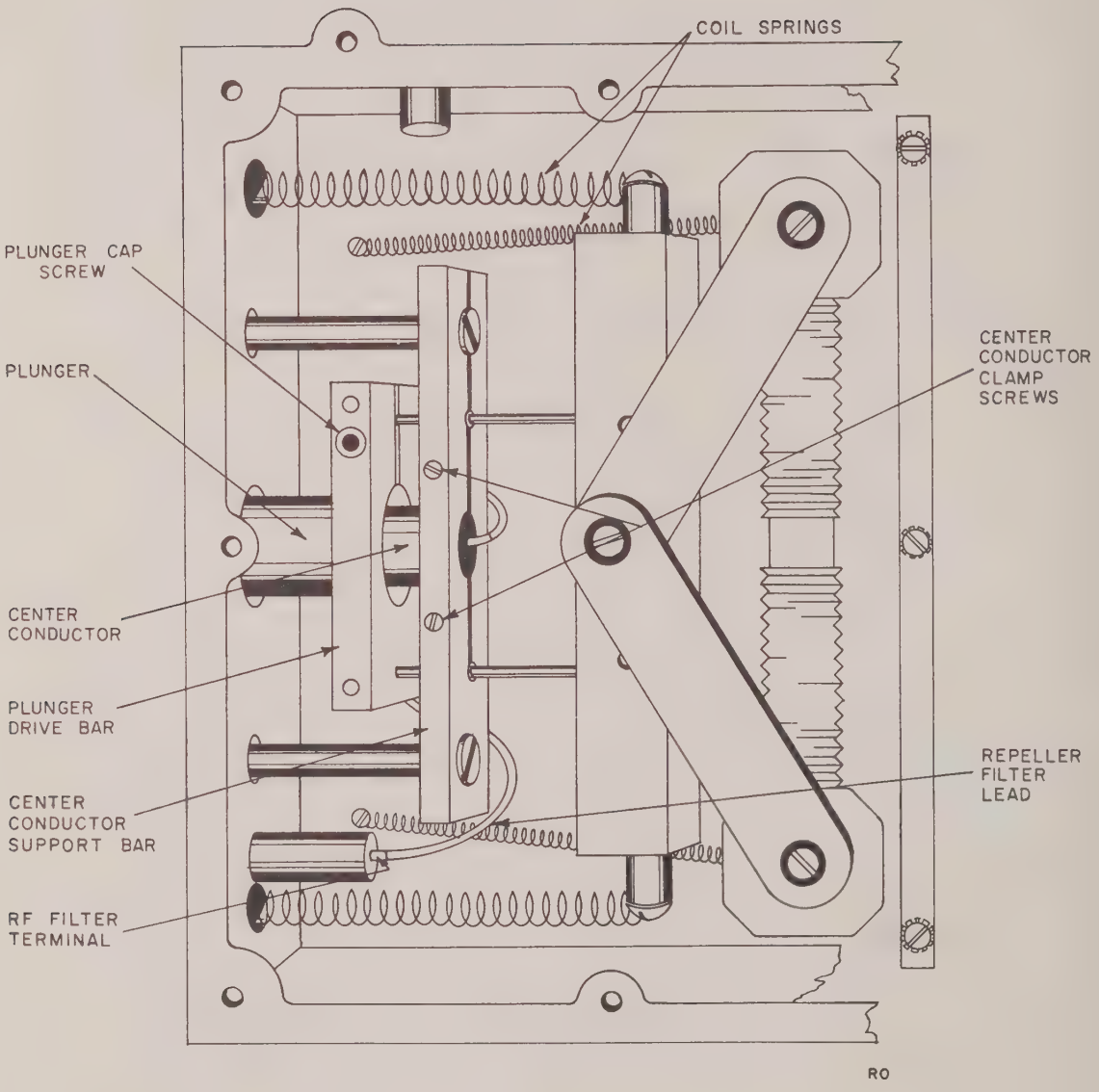


Figure 4-13. Frequency Drive Mechanism, Cover Plate Removed

4-13 CALIBRATING THE FREQUENCY DIAL

Replacing the klystron will usually reduce the accuracy of the kilomegacycles dial by several percent from its rated accuracy of 1%. If accuracy of frequency dial calibration is important, the following procedure can be used to restore accuracy. This procedure requires a wavemeter covering the frequency range of the signal generator and having an accuracy of better than 0.2%. In general, when a new klystron oscillator tube is installed it will be necessary to slip the frequency dial slightly to bring into calibration. In some cases, it may also be necessary to reset the plunger depth at the high frequency end of the band to re-establish the correct high frequency limit. There are no trimmers or other adjustments of that sort; all adjustments for frequency recalibration must be done mechanically.

To recalibrate the frequency dial following a change in klystron oscillator tube, proceed as follows:

a. Following initial voltage adjustments in Paragraph 4-12, set the MOD SELECTOR to CW and allow signal generator to warm up for 20 minutes.

b. Assuming that the repeller adjustments have been set for best operation of the new klystron, tune signal generator to the highest frequency at which the klystron will oscillate. Measure this frequency with the wavemeter.

c. If the klystron cannot be made to oscillate up to 11 KMC, refer to step 10 in the trouble shooting procedure.

d. If the klystron oscillates satisfactorily up to 11.1 KMC as read on the wavemeter, check the frequency dial calibration accuracy over the full frequency range. If the dial calibration is too high or too low over the entire range by a nearly equal amount, the frequency dial may be slipped into calibration by removing the frequency dial cover, loosening the dial hub and turning the dial a small amount.

e. If slipping the dial will not bring both the low and high ends of the frequency dial into calibration, the high end can first be correctly set by altering the depth of the cavity plunger slightly to obtain the correct upper frequency limit and then slip the dial to bring the low frequency end into calibration.

f. To set the high frequency limit of the klystron by shifting the plunger setting remove the bottom plate from the frequency drive casting to expose the plunger operating mechanism.

g. Adjust the signal generator to produce 11 KMC as read on the wavemeter.

h. Refer to Figure 4-13 and loosen the cap screw holding plunger in the plunger drive bar.

i. Holding the plunger in the 11 KMC position, adjust the frequency drive for a reading of 11 KMC on the dial. Tighten cap screw.

j. If oscillation stops when the plunger is moved, readjust the appropriate repeller voltage potentiometer to regain oscillation.

k. Recheck low end of frequency range noting frequency dial accuracy. If the dial is inaccurate, remove dial cover, loosen hub slightly and slip frequency dial to correct.

l. Recheck accuracy of frequency dial at main points across the band. Refine the foregoing adjustments to produce the best overall accuracy.

m. If the frequency spread of a new klystron tube is much greater or less than that of the original tube, it may not be possible to use the original dial for the new tube. In this case, another klystron must be tried or a new frequency dial must be calibrated.

4-14 REPLACING AND RECALIBRATING THE ATTENUATOR

It is not expected that the attenuator dial will require recalibration unless the attenuator assembly is replaced. The attenuator is not ordinarily subject to change or breakage. Small improvements in accuracy may be made by slipping the attenuator dial on the front panel slightly on its shaft to bring into calibration.

Following replacement of the probe, the attenuator assembly must be adjusted for the correct and safe operating depth. The following discussion is divided into two parts. The first concerns the replacement of the attenuator probe, and the second concerns the recalibration of the attenuator dial.

CAUTION

There are high voltages on V112 and V113 tube shields. Turn off the instrument completely when replacing the attenuator and power monitor probe assemblies.

To determine if the output attenuator is defective, measure the resistance between the center terminal of the RF OUTPUT jack and ground. The resistance should be approximately 50 ohms. A higher resistance indicates the film resistor that composes the pickup loop is damaged and the attenuator probe and cable must be replaced.

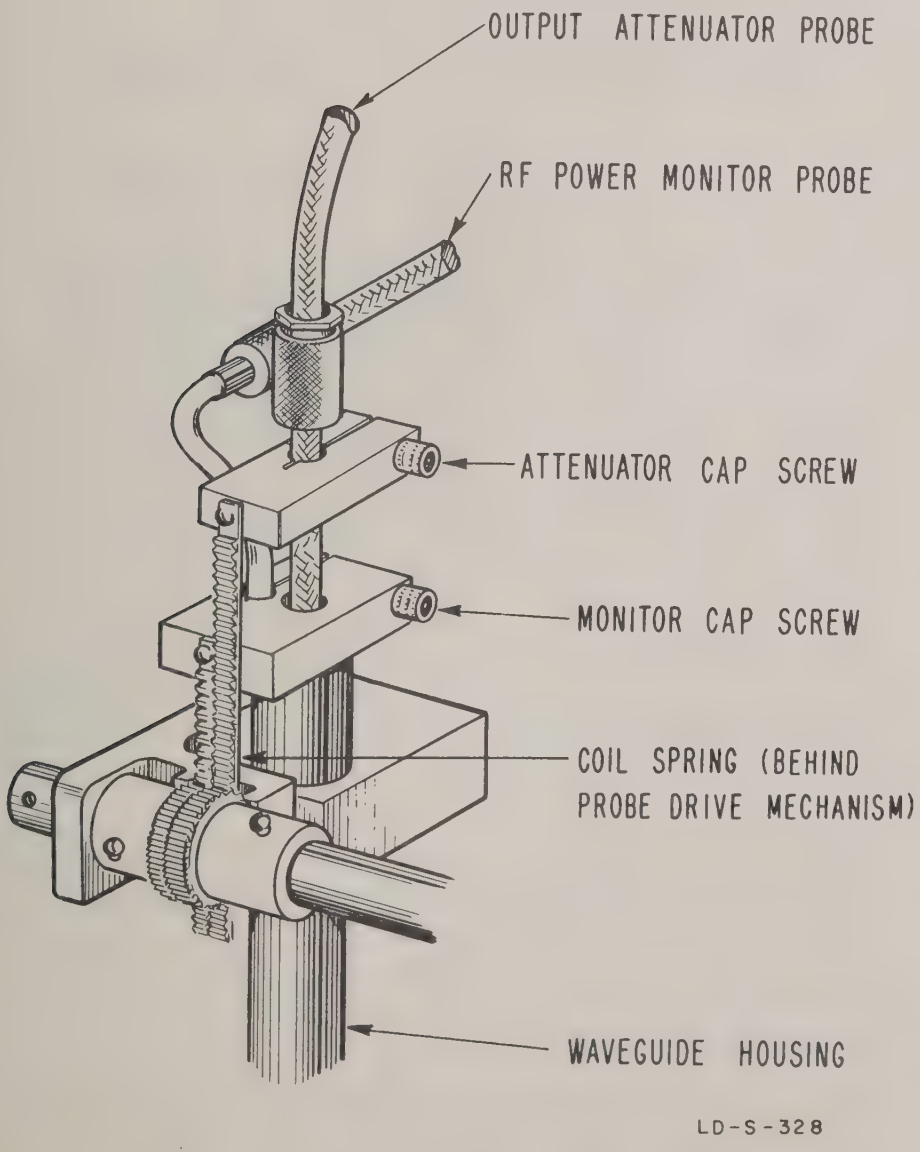


Figure 4-14. Detail Showing Attenuator and Monitor Probe Assemblies

Replacing the Attenuator Probe

To replace the attenuator probe assembly, proceed as follows:

a. With the signal generator removed from its cabinet and disconnected from the power source, unscrew the knurled nut behind the RF OUTPUT jack and pull attenuator cable from the jack. The center connector and spacing beads remove with cable. A new replacement assembly includes these parts already installed.

b. Free the attenuator cable from small clamp and feed cable out top of instrument noting the routing of the cable around the various decks.

c. Loosen the cap screw shown in Figure 4-14 on the mounting block carried by the rack gear mechanism. Pull probe straight out.

d. Insert new probe carefully to the same depth as the original probe making sure that the ground end of the pick up loop points toward the resonator cavity (to the right when facing the instrument).

e. Tighten set screw finger tight so that minor adjustment of the probe depth is still possible.

f. Carefully thread the cable under the cable clamp and around the casting to the front panel. DO NOT twist cable more than a quarter of a turn.

g. Remount RF OUTPUT connector. Tighten cable clamp.

h. After this assembly is replaced an error of a few decibels may exist in the calibration of the attenuator dial. Calibration may be checked in the following manner.

Recalibrating the Attenuator Dial:

Check POWER METER calibration before recalibrating the attenuator dial. See Paragraph 4-21, steps h, i, and j.

The following equipment will be required for attenuator calibration: ℗ Model 430C Microwave Power Meter or equivalent with suitable detector mount and adapters. (See Table 4-1).

a. Turn on the equipment and allow the signal generator to warm up with the MOD SELECTOR in the CW position for at least twenty minutes.

b. Place the MOD SELECTOR on OFF.

c. Tune the signal generator to 9 KMC.

d. Adjust the ZERO SET control to zero the POWER SET meter. Zero meter reading on the 430B Power Meter.

e. Place the MOD SELECTOR switch in the CW position.

f. Adjust the POWER SET control so that the power set meter reads 0 dbm (red line at mid scale).

g. Adjust the power detector mount for a maximum reading on the -5 dbm range of the Model 430B Power Meter.

h. Adjust the OUTPUT ATTEN control to read -7 dbm.

WARNING HIGH VOLTAGE

High voltage is present on the shields of the two tubes just above the attenuator assembly, also on the green lead below the attenuator assembly and at the terminals on the potentiometer above the frequency drive casting. Be extremely careful not to touch these components when adjusting the attenuator probe with instrument turned on.

i. Gently adjust the probe depth so that the external power meter indicates -7 dbm. Tighten the cap screw on the attenuator probe.

An initial setting has now been made that will be accurate within approximately ±5 decibels. To refine this setting and obtain the original calibration accuracy of ±2 decibels or better, it is necessary to measure the output of the signal generator across the frequency range and construct a graph showing the frequency response of the instrument. Figure 4-15 shows such a graph with a typical response curve after the power output curve has been centered about the -7 dbm reference level. The final adjustment is made by slipping the attenuator dial, while measuring the rf output level at a convenient frequency on the curve, to bring the total power spread to be within the ±2 db limits of the -7 dbm reference level. The limits are indicated by the heavy transverse lines above and below the -7 dbm center line.

Proceed as follows:

j. Assuming that the signal generator is at normal operating temperature, set the MOD SELECTOR to OFF and zero both the POWER SET meter and external power meter.

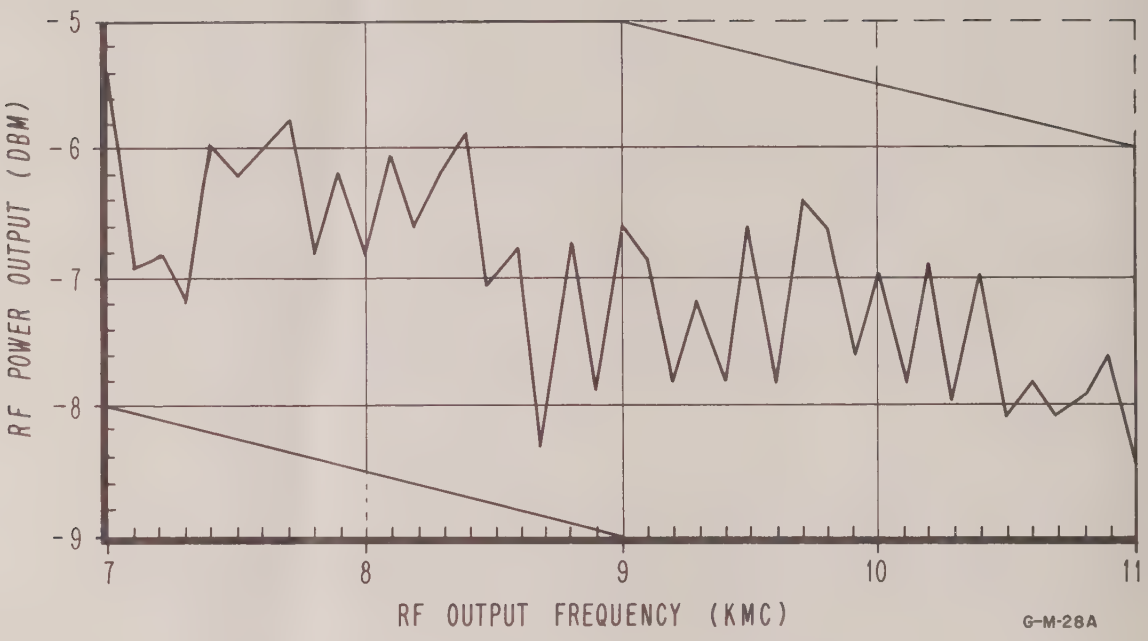


Figure 4-15 Graph Showing Typical Response Curve of Output Attenuator System

k. Set the MOD SELECTOR to CW and tune frequency dial to 7 KMC.

l. Adjust the POWER SET control so that the POWER SET meter indicates 0 dbm (midscale).

m. Check that the OUTPUT ATTEN control is set to -7 dbm.

n. Tune the detector mount for maximum output and record the reading on the external power meter.

o. Repeat steps a through f every 200 mc from 7 kmc to 11 kmc. Plot the resulting data as a response curve such as the one shown in Figure 4-15.

p. This curve should consist of a series of troughs and peaks with a maximum range of ±2 dbm.

q. Equalize the maximum excursions on each side of -7 dbm by slipping the attenuator dial.

The dial is made free of the drive shaft by removing the hub cover from the center of the attenuator dial and loosening the two Allen screws in the periphery of the dial hub.

4-15 CHECKING AND TROUBLE SHOOTING THE PULSER SECTION

Trouble shooting the pulser section of the signal generator requires a high speed synchroscope to measure waveforms. By referring to the block diagram in Figure 4-6 and measuring the waveforms at front panel jacks and at various points in the circuit a fault can quickly be localized to a small portion of the pulser circuits.

Briefly, the operation of the pulser section is as follows:

a. When the MOD SELECTOR is in the INT position, V103 is a free running multivibrator that generates an approximate square wave, the frequency of which is controlled by the front panel PULSE RATE control. The output is differentiated and applied to pulse shaper V104.

b. The shaped pulse from V104 is applied to both the front panel SYNC OUT jack and to the pulse delay circuit.

c. The pulse delay multivibrator V107 is a one shot multivibrator producing one output pulse for each input pulse. The length of the output pulse is controlled by the front panel PULSE DELAY control.

d. The adjustable trailing edge from the pulse delay multivibrator is applied through amplifier-inverter V107 to thyratron pulse shaper V110 which provides a strong, fast output pulse to the delayed sync out and pulse width circuits.

e. When the MOD SELECTOR is in the INT FM position, thyratron V110 serves as a relaxation oscillator supplying a sawtooth wave to the repeller circuits of the klystron.

f. The delayed sync out circuit utilizes a one shot multivibrator to provide a strong, fast pulse of a particular shape to the DELAYED SYNC OUT jack on the front panel.

g. The pulse width circuit utilizes a one shot multivibrator producing one output pulse for each input pulse . The width of the output pulse is controlled by the front panel PULSE WIDTH control.

h. The entire negative portion of the adjustable width output pulse from pulse width multivibrator V101 is applied to modulator tube V113.

i. The modulator tube which is normally in a conducting condition to hold the klystron cut off is cut off by the negative pulse from pulse length multivibrator allowing the klystron to conduct for the length of the pulse.

TABLE 4-5

TROUBLE SHOOTING CHART -- PULSER SECTION

1. Check square wave operation. This check tests the pulse rate mv V103. (sq. wave is approximately 3 db down from CW on output meter.)		
Incorrect square wave frequency:	Out of adjustment or defective V103.	Adjust pulse rate as described in paragraph 4-16.
No square waves:	Defective V103	Replace V103 and adjust rate as above.
2. Check internal FM operation. This check tests thyratron V110 and diode V108.		
No mode pattern obtainable:	Defective V110, V108B.	Replace without further adjustment.
3. Measure pulse at SYNC OUT jack. This check tests pulse shaper V104 and cathode follower V105B.		
Poor pulse shape or no pulse:	Defective V104 or V105B	Replace V104 or V105B without further adjustment.
4. Check pulse at DELAYED SYNC OUT jack. This check tests delayed sync out V115, pulse delay mv V107, amplifiers V105B and V109A and coupling diode V106.		
Poor DELAYED SYNC output pulse shape:	Defective V115 or V109B	Replace V105 or V109 without further adjustment.
Inadequate delay time:	Out of adjustment or defective V107	Adjust pulse delay as described in paragraph 4-17.
No output pulse:	Defective V106, V107, V109 or V115.	Replace V106, V107, V109 or V115, make adjustments as required.
5. Check rf output pulse. This check tests the remaining pulser circuit pulse length multivibrator V111.		
Inadequate pulse length:	Out of adjustment or defective V111.	Adjust pulse length as described in paragraph 4-18.
6. Apply external signal to SYNC IN jack.		
No rf output pulse:	Defective V101, V102.	

j. Clamp V111 protects the signal voltage applied to the Klystron control grid from going positive farther than -975 volts.

k. In general, coupling between circuits is done through clipping and/or clamping diodes. The diodes provide effective decoupling between circuits, eliminating unwanted portions (overshoot, extraneous pulses, and the unwanted polarity) of trigger pulses to prevent interaction between multivibrators. If interaction is present, it will most often be seen as erratic or double pulsing and is caused by extra-triggering of a multivibrator by some portion of a pulse from another multivibrator, or by a multivibrator that is free-running.

To trouble shoot the pulser section of the 620A Signal Generator, make the tests indicated on page 4-34 in the order given. This order checks small circuit portions at a time at the front panel without going into the pulser circuitry.

4-16 CALIBRATING THE PULSE RATE DIAL

Replacing V-103 may lessen the accuracy of the PULSE RATE dial, but will not otherwise affect the performance of the signal generator. It should be noted, however, that the calibration of this dial is only approximate.

To calibrate the PULSE RATE dial, proceed as follows:

a. Connect SYNC OUT connector to the SYNC input of an oscilloscope.

b. Connect DELAYED SYNC OUT connector to the oscilloscope vertical amplifier input.

c. Connect the output of a calibrated audio oscillator to the oscilloscope vertical amplifier input through a 10,000 - ohm isolating resistor.

d. Set the MOD SELECTOR switch to INT, and the pulse rate to 4000 pps (SYNC SELECTOR switch to X10 and PULSE RATE control to 400).

e. Adjust the amplitude controls on the oscilloscope and oscillator to obtain a convenient scope presentation.

f. Set the oscillator to 4000 cps.

g. Adjust the sweep rate of the oscilloscope so that several cycles of sine wave occupy the full width of the screen.

h. Adjust R-112 so that the generated pulse rate is 4000 pps. When the repetition rate of the pulses is 4000 pps, each pulse will be superimposed upon each cycle of the sine wave. Adjust R-112 until the pattern is stationary and all slope is removed (top of pulses in a straight, horizontal line.)

i. Set the sync Selector to X1 with the other controls remaining unchanged. Set oscillator to 400 cps.

j. Adjust R-113 so that the generated pulse rate is 400 pps.

k. Set the PULSE RATE control to 40 pps, with the other controls remaining unchanged. Set oscillator to 40 cps.

l. Adjust R-117 so that the generated pulse rate is 40 pps.

m. Set the SYNC SELECTOR to X10 and check the calibration of the PULSE RATE dial in vicinity of 40. R-117 can be readjusted to improve calibration accuracy if desired.

n. Refine the above adjustments as desired or for best overall accuracy.

4-17 CALIBRATING THE PULSE DELAY DIAL

Replacing V-107 may lessen the accuracy of the PULSE DELAY dial. After replacing V-107, the following procedure can be used to adjust the delay calibration, however, the calibration of the PULSE DELAY dial is intended only to be approximate.

a. Connect the DELAYED SYNC OUT terminal to the vertical input of an oscilloscope having an accurately calibrated sweep.

b. Synchronize the oscilloscope from the SYNC OUT connector.

c. Set PULSE DELAY control to 300 microseconds.

d. Adjust R-133 to give a delay of 300 microseconds as measured on the calibrated oscilloscope screen.

e. Set PULSE DELAY control to 3 microseconds as read on oscilloscope screen. If necessary, slip the PULSE DELAY dial on its shaft to make calibration accurate. The delay is indicated by the interval between the start of the oscilloscope trace and the leading edge of the Delayed Sync Out pulse.

f. Repeat steps c and d for best overall calibration.

4-18 CALIBRATING THE PULSE WIDTH DIAL

Replacing V-111 may lessen the accuracy of the PULSE WIDTH dial which is intended to be accurate within 20% or 1 microsecond, whichever is greater. To calibrate the PULSE WIDTH dial proceed as follows:

a. Connect the RF OUTPUT through a crystal detector to the vertical input of an oscilloscope having an accurately calibrated sweep.

b. Connect the SYNC OUT connector to the sync connector on the oscilloscope.

c. Set the PULSE WIDTH control to 10 microseconds.

d. Adjust R-156 so that the width of the generated pulse is 10 microseconds as measured on the oscilloscope.

e. Set the PULSE WIDTH control to 1 microsecond.

f. If necessary, slip dial to read 1 microsecond.

g. Repeat steps c, d, e, and f for best overall calibration accuracy.

h. The width of the rf pulse will vary approximately 1/4 microsecond as the generator is tuned through its rf range. The above adjustments can be made for best accuracy at any desired rf frequency.

4-19 REPLACING THE REPELLER TRACKING POTENTIOMETER

To replace the repeller tracking potentiometer R174 on the frequency drive casting, refer to Figure 4-16 and proceed as follows:

a. Disconnect blower tube at cavity.

b. Remove the four flat head screws on each side of the front panel that hold the panel assembly to the side gussets. Pull panel assembly away from chassis to give access to the repeller potentiometer.

c. Remove leads from terminals on potentiometer.

d. Remove Tru-Arc ring and potentiometer rear cover.

e. Loosen only the two set screws holding potentiometer shaft in the coupler. Do not loosen screws holding coupler to front panel shaft.

f. Remove the three screws holding the potentiometer to the mounting ring and withdraw potentiometer. Do not loosen screws holding mounting ring to casting.

g. Remove rear cover and place shaft of new potentiometer in coupler. Do not tighten the set screws.

h. Position the new potentiometer with the terminals near the top and replace the three mounting screws and spacers. Position the potentiometer so that shaft does not bind in coupler during any portion of coupler rotation. Tighten mounting screws.

i. With an ohmmeter connected between the orange and blue leads on the potentiometer, turn the frequency dial control to where the microswitch just operates (approx. 8.5 kmc); so the arm (blue lead) is exactly at the tap in the potentiometer. This point is the lowest resistance reading on ohmmeter.

j. Replace rear potentiometer cover and reconnect leads.

k. Tighten set screws in the coupler.

l. Reset repeller voltage adjustments as described in Paragraph 4-12.

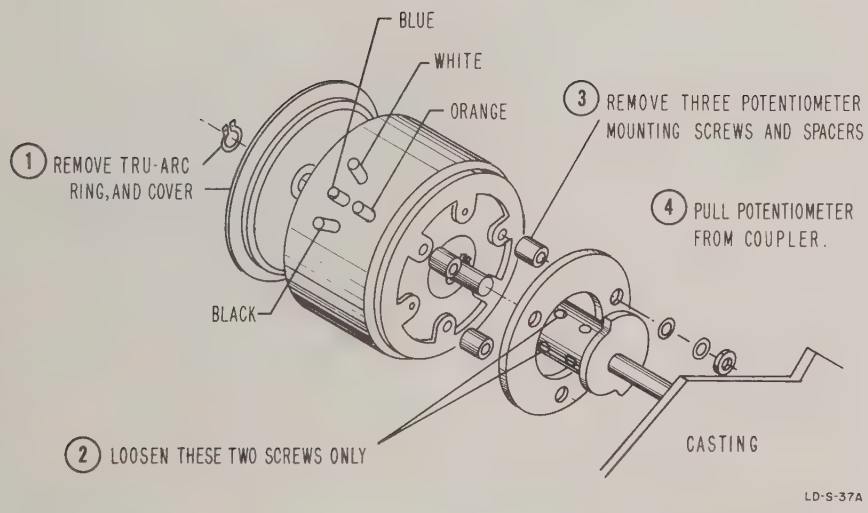


Figure 4-16. Detail Showing Repeller Potentiometer Removal

4-20 LUBRICATION

It is not expected that the mechanical parts of the signal generator will require lubrication within the first year of operation. Moving parts such as the attenuator and power monitor rack gears are lubricated at the factory with Moly Grease #1. The frequency drive gears behind the front panel and the drive mechanism shown in Figure 4-13 are lubricated with Moly Oil, SAE 20. The cavity plunger is permanently lubricated during manufacture and requires no subsequent lubrication.

4-21 REPLACING RF POWER MONITOR AND THERMISTOR R202

The power level within the resonator is sampled by a pickup probe and fed through a coaxial cable to a bead thermistor in a block mounted on the back of the front panel. Like the rf attenuator pick-up loop, the actual monitor pickup loop consists of a resistive film on a glass bead at the end of the probe. To check the continuity of this loop, R351, disconnect the coaxial cable from the block by unscrewing the hex retainer nut, pull cable and attaching parts from block and measure the resistance between the center conductor and ground. The resistance should be approximately 50 ohms. To check the bead thermistor inside the block, remove the black and green leads connected to the long tube (from the output terminal) projecting from the right side of the block. Measure the resistance between the output terminal and ground; resistance should be between 1300 and 1800 ohms.

The thermistor assembly itself is replaceable by removing the end of the block, and unsoldering the lead from the small lug at the bottom of the filter on the side of the block. Remove the retaining ring which secures the thermistor cartridge and remove the cartridge assembly. Following replacement the POWER SET meter must be recalibrated as in steps h through k.

CAUTION

At all times protect the tips of both the attenuator and power monitor probes from mechanical damage. Do not scratch or touch the tips to other objects.

a. Remove screw holding the attenuator probe mounting block to its rack gear and remove probe from the waveguide housing.

b. Remove hex retainer nut holding power monitor cable in thermistor block on front panel. Pull cable and attaching parts from block. Do not lose attaching parts and note the order of components as placed on cable end.

c. Mark the power monitor probe exactly where it enters the top of the mounting block. The distance between this mark and the probe tip should be duplicated when the new probe is installed.

d. Loosen the set screw holding the probe in the mounting block. Remove probe.

e. With new probe marked at same distance from tip as old probe was in step c, insert new probe into mounting block so that ground end of pickup loop is to the right as viewed from front of signal generator and so that mark is at top of block. Tighten set screw.

f. Remove attaching parts from old probe cable and replace in correct order on new cable. See Figure 4-17. Insert cable into thermistor block and tighten retainer nut.

Figure 4-17. Power Monitor Cable Connector Assembly

g. Install attenuator probe with mounting block on rack gear.

h. Recalibrate the POWER SET meter as follows:

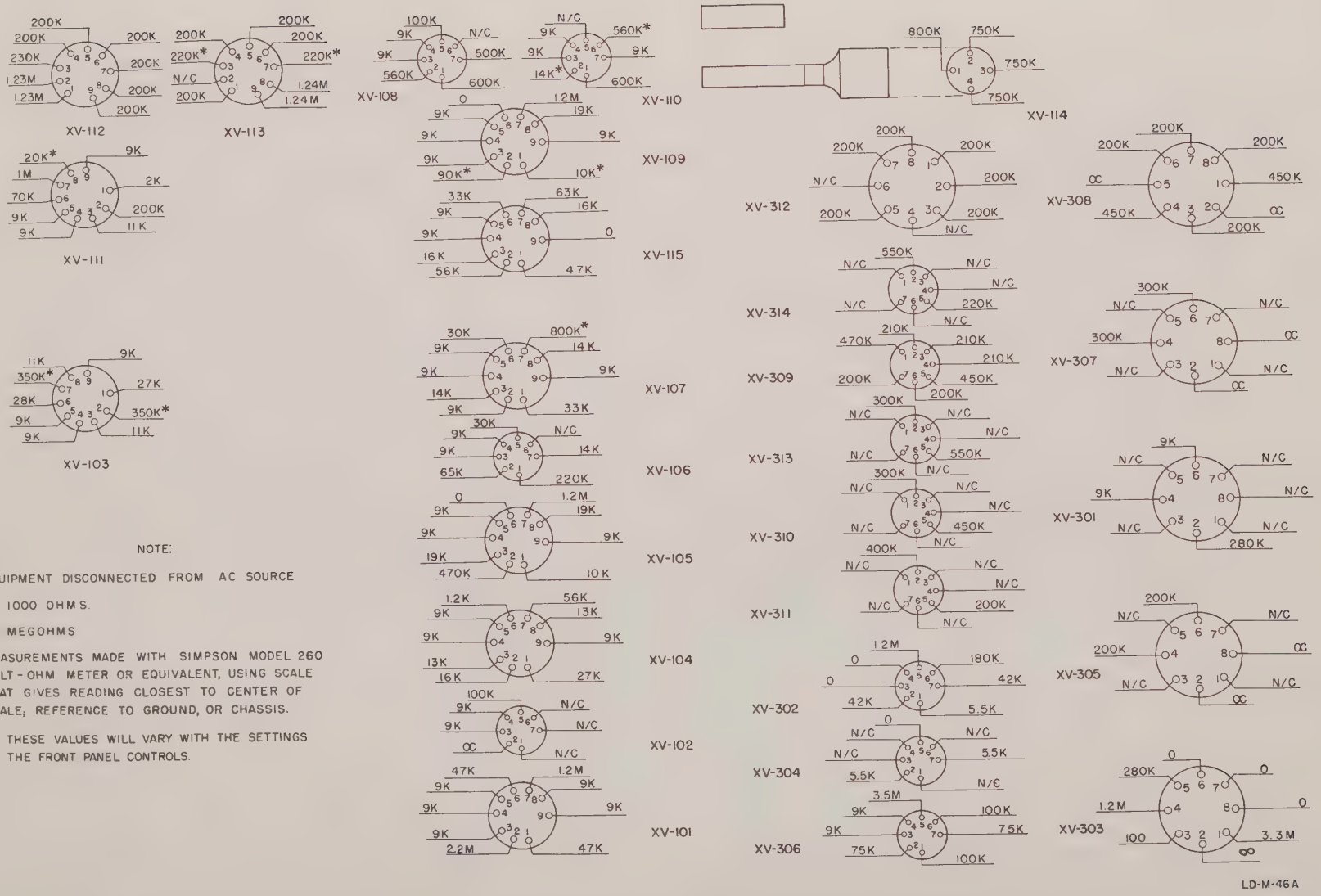
i. With signal generator turned on, tune across the frequency band noting the frequency giving lowest meter reading.

j. At the point of lowest output, adjust the POWER SET control for maximum meter reading. A reading substantially greater than mid-scale should be obtainable, if it is not it will be necessary to loosen the set screw holding the power monitor probe to re-set the depth sufficiently and obtain the required deflection on the meter

CAUTION: Use great care when making this adjustment. Do not run the probe into the cavity so that it strikes the klystron.

If the klystron is weak and does not put out the required power it would seem necessary to insert the power monitor probe still farther to obtain a normal power reading. This is not advised. The new power monitor probe should require only nominal re-setting (.02 inch) of the depth to obtain required power.

k. Recalibrate attenuator as described in Paragraph 4-14.



NOTE:

EQUIPMENT DISCONNECTED FROM AC SOURCE

K = 1000 OHMS.

M = MEGOHMS

MEASUREMENTS MADE WITH SIMPSON MODEL 260 VOLT-OHM METER OR EQUIVALENT, USING SCALE THAT GIVES READING CLOSEST TO CENTER OF SCALE; REFERENCE TO GROUND, OR CHASSIS.

* THESE VALUES WILL VARY WITH THE SETTINGS OF THE FRONT PANEL CONTROLS.

Figure 4-18 Tube Socket Resistance Measurements

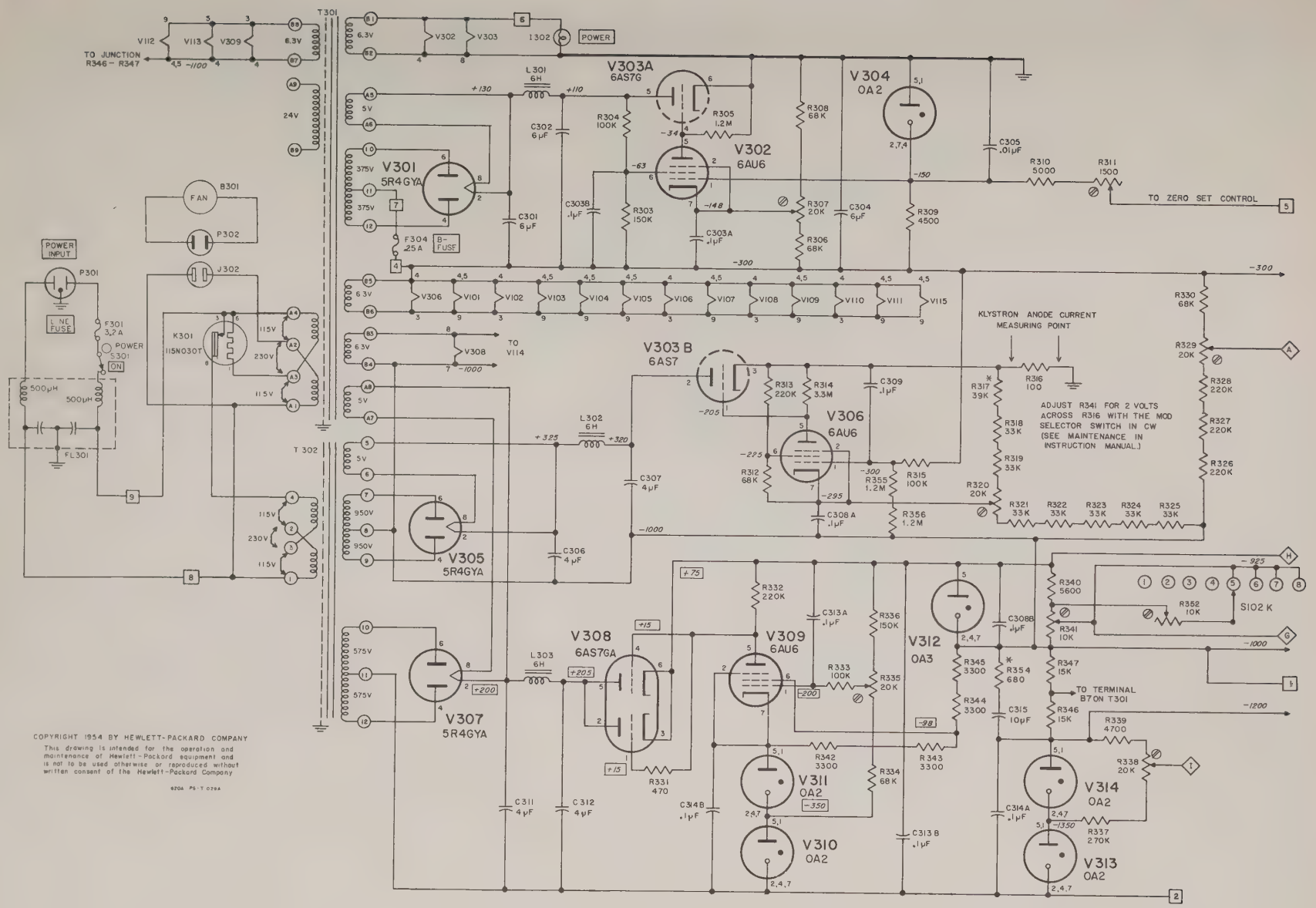


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Figure 4-19. Power Supply

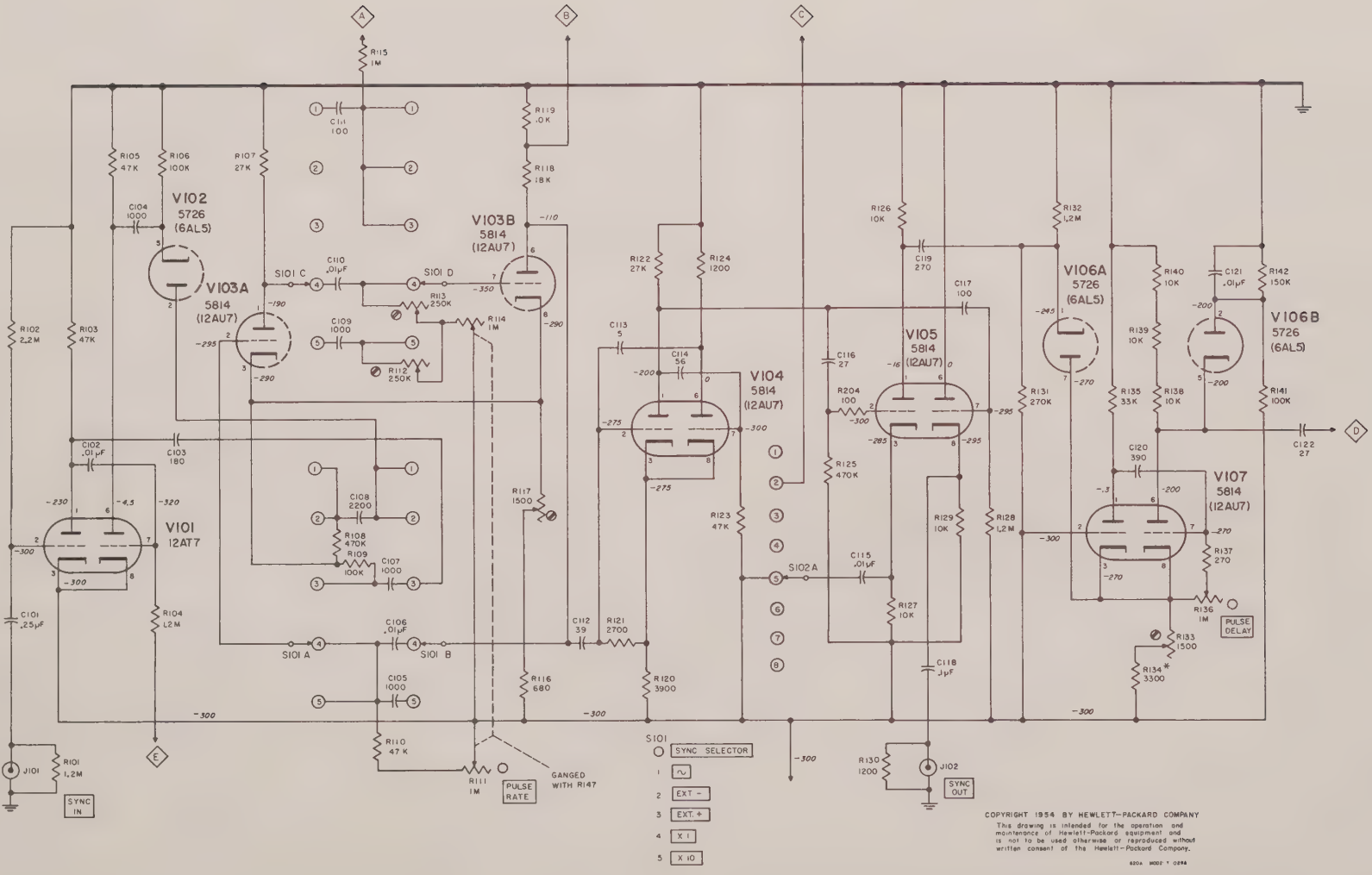


Figure 4-20. Modulator Section (Part I)

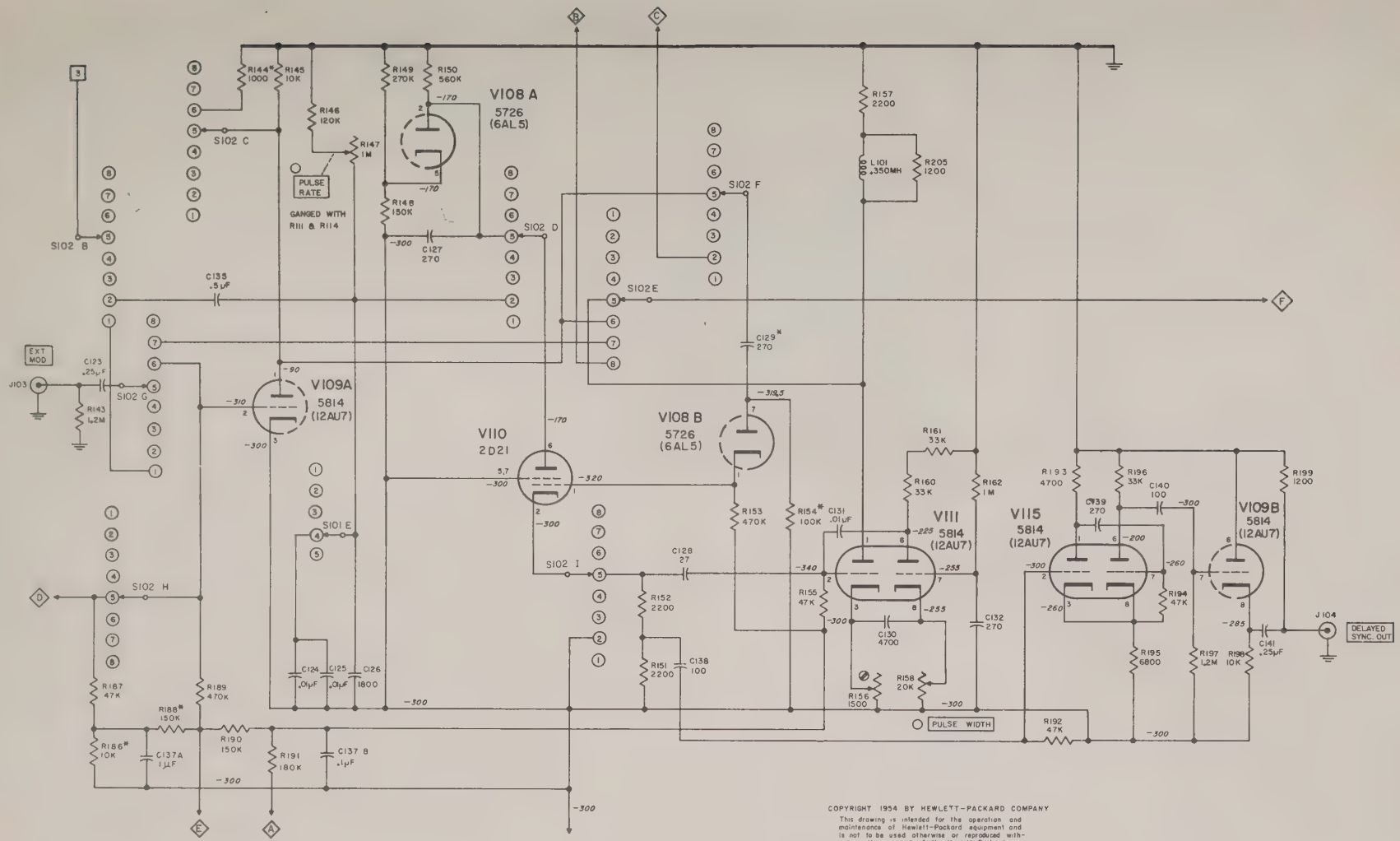
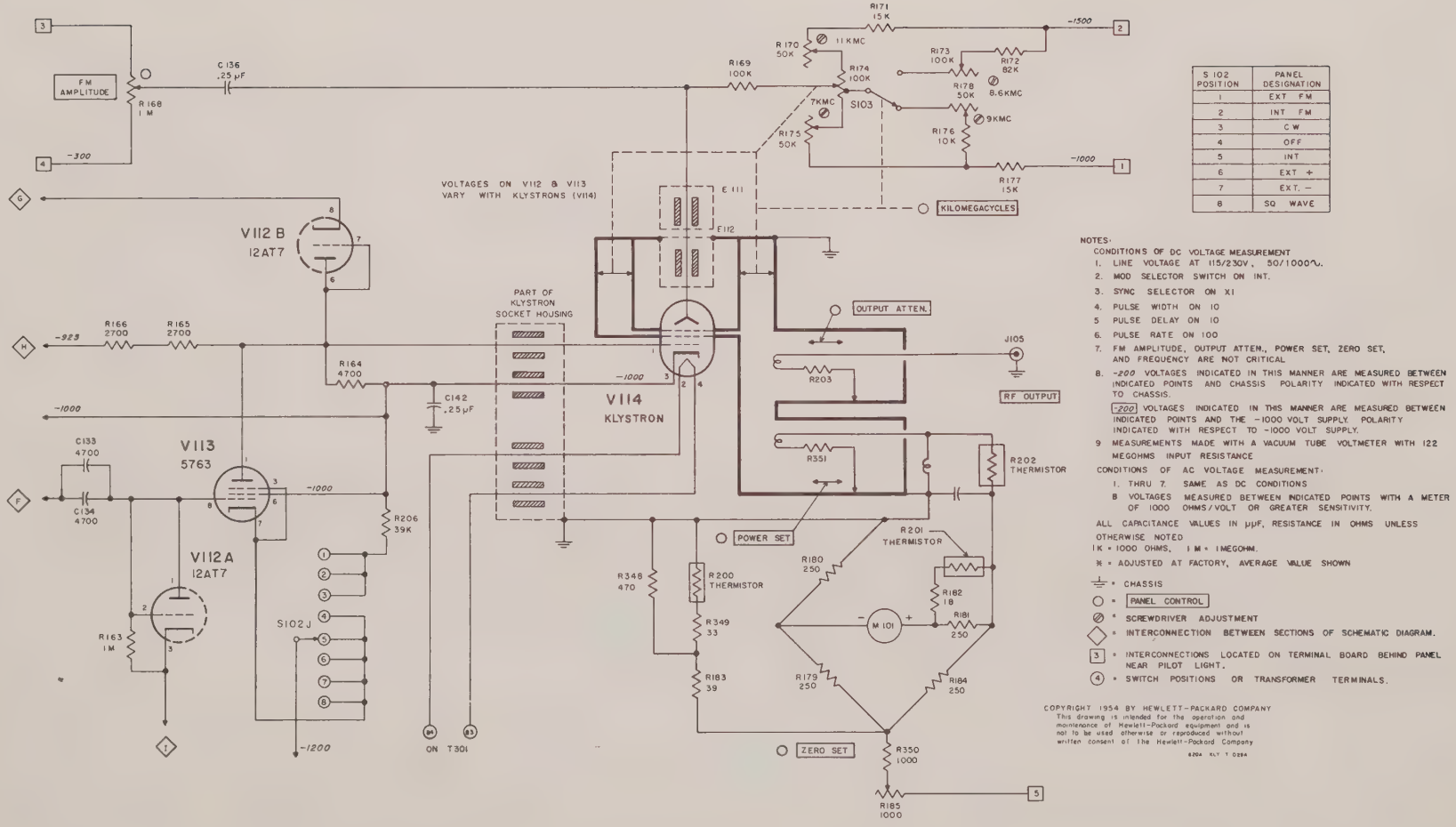


Figure 4-21. Modulator Section (Part II)



S 102 POSITION	PANEL DESIGNATION
1	EXT FM
2	INT FM
3	CW
4	OFF
5	INT
6	EXT +
7	EXT. −
8	SQ WAVE

NOTES:

CONDITIONS OF DC VOLTAGE MEASUREMENT

1. LINE VOLTAGE AT 115/230V, 50/1000∿.
2. MOD SELECTOR SWITCH ON INT.
3. SYNC SELECTOR ON X1
4. PULSE WIDTH ON 10
5. PULSE DELAY ON 10
6. PULSE RATE ON 100
7. FM AMPLITUDE, OUTPUT ATTEN., POWER SET, ZERO SET, AND FREQUENCY ARE NOT CRITICAL
8. -200 VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND CHASSIS POLARITY INDICATED WITH RESPECT TO CHASSIS.

[-200] VOLTAGES INDICATED IN THIS MANNER ARE MEASURED BETWEEN INDICATED POINTS AND THE −1000 VOLT SUPPLY POLARITY INDICATED WITH RESPECT TO −1000 VOLT SUPPLY.

9 MEASUREMENTS MADE WITH A VACUUM TUBE VOLTMETER WITH 122 MEGOHMS INPUT RESISTANCE

CONDITIONS OF AC VOLTAGE MEASUREMENT:

1. THRU 7. SAME AS DC CONDITIONS

8 VOLTAGES MEASURED BETWEEN INDICATED POINTS WITH A METER OF 1000 OHMS/VOLT OR GREATER SENSITIVITY.

ALL CAPACITANCE VALUES IN μμF, RESISTANCE IN OHMS UNLESS OTHERWISE NOTED

1K = 1000 OHMS, 1 M = 1MEGOHM.

% = ADJUSTED AT FACTORY, AVERAGE VALUE SHOWN

⏚ = CHASSIS

○ = PANEL CONTROL

⊘ = SCREWDRIVER ADJUSTMENT

◇ = INTERCONNECTION BETWEEN SECTIONS OF SCHEMATIC DIAGRAM.

[3] = INTERCONNECTIONS LOCATED ON TERMINAL BOARD BEHIND PANEL NEAR PILOT LIGHT.

(4) = SWITCH POSITIONS OR TRANSFORMER TERMINALS.

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8204 KLY 1 0284

Figure 4-22. Klystron Section

SECTION V

REPLACEABLE PARTS

5-1 INTRODUCTION

This section contains information for ordering replacement parts for the Model 620A SHF Signal Generator.

Table 5-1 lists replaceable parts in alpha-numerical order of their reference designators. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

a. Reference designator.

b. Full description of the part.

c. Manufacturer of the part in a five-digit code; see list of manufacturer in appendix.

d. Hewlett-Packard stock number.

e. Total quantity used in the instrument (TQ column).

f. Recommended spare quantity for complete maintenance during one year of isolated service (RS column).

5-2 ORDERING INFORMATION

To order a replacement part, address order or inquiry either to your authorized Hewlett-Packard sales office or to

CUSTOMER SERVICE
Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California,

or, in Western Europe, to

Hewlett-Packard S. A.
Rue du Vieux Billard No. 1
Geneva, Switzerland.

Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designator.

d. Description.

To order a part not listed in Table 5-1, give a complete description of the part and include its function and location.

Table 5-1. Replaceable Parts (Sheet 1 of 13)

Ckt Ref	Description	Mfr *	℗ Stock No.	TQ*	RS*		
B1 thru B300	Not assigned						
B301	Motor, AC	01349	3140-0005	1	1		
	Blade, fan	06812	3160-0011	1	1		
	Filter, air	82866	3150-0004	1	1		
C1 thru C100	Not assigned						
C101	Capacitor: fixed, paper, 0.25 μf ±10%, 1000 vdcw	00853	0160-0081	3	1		
C102	Capacitor: fixed, mica, 0.01 μf ±10%, 300 vdcw	00853	0140-0008	7	2		
C103	Capacitor: fixed, mica, 180 pf ±10%, 500 vdcw	00853	0140-0023	1	1		
C104,105	Capacitor: fixed, silver mica, 1000 pf ±5%, 500 vdcw	76433	0140-0018	5	1		
C106	Capacitor: fixed, mica, 0.01 μf ±5%, 500 vdcw	00853	0140-0009	2	1		
C107	Same as C104						
C108	Capacitor: fixed, mica, 2200 pf ±10%, 500 vdcw	00853	0140-0024	1	1		
C109	Same as C104						
C110	Same as C106						
C111	Capacitor: fixed, mica, 100 pf ±10%, 500 vdcw	76433	0140-0054	4	1		
C112	Capacitor: fixed, mica, 39 pf ±10%, 500 vdcw	00853	0140-0021	1	1		
C113	Capacitor: fixed, mica, 5 pf ±20%, 500 vdcw	00853	0140-0001	1	1		
C114	Capacitor: fixed, mica, 56 pf ±10%, 500 vdcw	76433	0140-0014	1	1		
C115	Same as C102						
C116	Capacitor: fixed, mica, 27 pf ±10%, 500 vdcw	00853	0140-0005	3	1		
C117	Same as C111						
C118	Capacitor: fixed, paper, 0.1 μf ±10%, 1000 vdcw	00853	0160-0090	2	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 2 of 13)

Ckt Ref	Description	Mfr *	℗ Stock No.	TQ*	RS*		
C119	Capacitor: fixed, mica, 270 pf ±10%, 500 vdcw	76433	0140-0015	4	1		
C120	Capacitor: fixed, mica, 390 pf ±5%, 500 vdcw	00853	0140-0016	1	1		
C121	Same as C102						
C122	Same as C116						
C123	Same as C101						
C124,125	Same as C102						
C126	Capacitor: fixed, mica, 1800 pf ±10%, 500 vdcw	00853	0140-0020	1	1		
C127	Same as C119						
C128	Same as C116						
C129	Same as C104. Optimum value selected at factory. Average value shown						
C130	Capacitor: fixed, mica, 4700 pf ±10%, 500 vdcw	76433	0140-0017	1	1		
C131	Same as C102						
C132	Same as C119						
C133,134	Capacitor: fixed, mica, 4700 pf ±10%, 2500 vdcw	00853	0140-0019	2	1		
C135	Capacitor: fixed, paper, 0.5 μf ±10%, 600 vdcw	00853	0160-0087	1	1		
C136	Capacitor: fixed, paper, 0.25 μf ±10%, 1500 vdcw	00853	0160-0088	2	1		
C137	Capacitor: fixed, paper, 2 sections 0.1 μf/sect +20% -10%, 1000 vdcw	00853	0160-0089	5	2		
C138	Same as C111						
C139	Same as C119						
C140	Same as C111						
C141	Same as C101						
C142	Same as C136						
C143 thru C300	Not assigned						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 3 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
C301,302	Capacitor: fixed, paper, 6 µf ±10%, 600 vdcw	00853	0160-0078	3	1		
C303	Same as C137						
C304	Same as C301						
C305	Same as C102						
C306,307	Capacitor: fixed, paper, 4 µf ±10%, 2000 vdcw	00853	0160-0085	2	1		
C308	Same as C137						
C309	Same as C118						
C310	Not assigned						
C311,312	Capacitor: fixed, paper, 4 µf ±10%, 1500 vdcw	00853	0160-0086	2	1		
C313,314	Same as C137						
C315	Capacitor: fixed, electrolytic, 10 µf -10% +100%, 300 vdcw	00853	0180-0009	1	1		
DS1 thru DS301	Not assigned						
DS302	Lamp, incandescent: 6-8 volts, 0.15 amp, #47	24455	2140-0009	1	1		
E1 thru E110	Not assigned						
E111	Filter, RF, Cylindrical, 4" long (mounts in castings)	28480	618B-27	1	1		
E112	Filter, repeller	28480	620A-36M	1	1		
F1 thru F300	Not assigned						
F301	Fuse, cartridge: 3.2 amp (115 v operation) Fuse, cartridge: 1.6 amp (230 v operation)	71400 71400	2110-0013 2110-0005	1	10		
F302,303	Not assigned						
F304	Fuse, cartridge: 0.25 amp	71400	2110-0018	1	10		
FL1 thru FL300	Not assigned						
FL301	Filter, line	04732	9110-0014	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 4 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
J1 thru J100	Not assigned						
J101	Connector and Cable Assembly SYNC IN	28480	618B-16G	1	1		
J102	Connector and Cable Assembly SYNC OUT	28480	618B-16H	1	1		
J103	Connector and Cable Assembly EXT. MOD	28480	618B-16F	1	1		
J104	Connector and Cable Assembly DE-LAYED SYNC OUT	28480	618B-16J	1	1		
J105	Connector, Part of RF Attenuator Assy						
K1 thru K300	Not assigned						
K301	Relay, time delay: SPST	70563	0490-0009	1	1		
L1 thru L100	Not assigned						
L101	Reactor: 0.35 MH	28480	618B-60A	1	1		
L102 thru L300	Not assigned						
L301	Reactor: choke, filter, 6H @ 90 MA	28480	9110-0010	2	1		
L302	Reactor: choke, filter, 6H @ 30 MA	28480	9110-0011	1	1		
L303	Same as L301						
M1 thru M100	Not assigned						
M101	Meter: 200 microammeter	65092	1120-0045	1	1		
P1 thru P300	Not assigned						
P301	Cable, power	70903	8120-0015	1	1		
P302	Connector, male: 2 contact	71785	1251-0018	1	1		
R1 thru R100	Not assigned						
R101	Resistor: fixed, composition, 1.2 megohms ±10%, 1 watt	01121	0690-1251	7	2		
R102	Resistor: fixed, composition, 2.2 megohms ±10%, 1 watt	01121	0690-2251	1	1		
R103	Resistor: fixed, composition, 47,000 ohms ±10%, 1 watt	01121	0690-4731	8	2		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 5 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
R104	Same as R101						
R105	Same as R103						
R106	Resistor: fixed, composition, 100,000 ohms ±10%, 1 watt	01121	0690-1041	7	2		
R107	Resistor: fixed, composition, 27,000 ohms ±10%, 2 watts	01121	0693-2731	2	1		
R108	Resistor: fixed, composition, 470,000 ohms ±10%, 1 watt	01121	0690-4741	4	1		
R109	Same as R106						
R110	Same as R103						
R111	Resistor: variable, composition, linear taper, 1 megohm ±10%, 3 tandem sections, ganged to R114 and R147	01121	2100-0059	1	1		
R112,113	Resistor: variable, composition, 250,000 ohms ±10%	01121	2100-0029	2	1		
R114	Part of R111; not separately replaceable						
R115	Resistor: fixed, composition, 1 megohm ±10%, 1 watt	01121	0690-1051	3	1		
R116	Resistor: fixed, composition, 680 ohms ±10%, 1 watt	01121	0690-6811	2	1		
R117	Resistor: variable, composition, linear taper, 1500 ohms ±10%	01121	2100-0025	4	1		
R118	Resistor: fixed, composition, 18,000 ohms ±10%, 2 watts	01121	0693-1831	1	1		
R119	Resistor: fixed, composition, 10,000 ohms ±10%, 2 watts	01121	0693-1031	6	2		
R120	Resistor: fixed, composition, 3900 ohms ±10%, 1 watt	01121	0690-3921	1	1		
R121	Resistor: fixed, composition, 2700 ohms ±10%, 1 watt	01121	0690-2721	1	1		
R122	Same as R107						
R123	Same as R103						
R124	Resistor: fixed, composition, 1200 ohms ±10, 1 watt	01121	0690-1221	4	1		
R125	Same as R108						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 6 of 13)

Ckt Ref	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R126,127	Resistor: fixed, composition, 10,000 ohms ±10%, 1 watt	01121	0690-1031	5	2		
R128	Same as R101						
R129	Same as R126						
R130	Same as R124						
R131	Resistor: fixed, composition, 270,000 ohms ±10%, 1 watt	01121	0690-2741	3	1		
R132	Same as R101						
R133	Same as R117						
R134	Resistor: fixed, composition, 3300 ohms ±10%, 1 watt. Optimum value selected at factory. Average value shown.	01121	0690-3321	1	1		
R135	Resistor: fixed, composition, 33,000 ohms ±10%, 2 watts	01121	0693-3331	11	3		
R136	Resistor: variable, composition, 1 megohm ±20%, 1/4 watt	01121	2100-0047	1	1		
R137	Resistor: fixed, composition, 270 ohms ±10%, 1 watt	01121	0690-2711	1	1		
R138, 139, 140	Same as R119						
R141	Same as R106						
R142	Resistor: fixed, composition, 150,000 ohms ±10%, 1 watt	01121	0690-1541	4	1		
R143	Same as R101						
R144	Resistor: fixed, composition, 1000 ohms ±10%, 1 watt. Optimum value selected at factory. Average value shown.	01121	0690-1021	1	1		
R145	Same as R119						
R146	Resistor: fixed, composition, 120,000 ohms ±10%, 1 watt	01121	0690-1241	1	1		
R147	Part of R111; not separately replaceable						
R148	Same as R142						
R149	Same as R131						
R150	Resistor: fixed, composition, 560,000 ohms ±10%, 1 watt	01121	0690-5641	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 7 of 13)

Ckt Ref	Description	Mfr *	℗ Stock No.	TQ*	RS*		
R151, 152	Resistor: fixed, composition, 2200 ohms ±10%, 1 watt	01121	0690-2221	3	1		
R153	Same as R108						
R154	Same as R106; Optimum value selected at factory. Average value shown.						
R155	Same as R103						
R156	Same as R117						
R157	Same as R151						
R158	Resistor: variable, composition, 20,000 ohms	01121	2100-0051	1	1		
R159	Not assigned						
R160,161	Same as R135						
R162,163	Same as R115						
R164	Resistor: fixed, composition, 4700 ohms ±10%, 1 watt	01121	0690-4721	3	1		
R165,166	Resistor: fixed, composition, 2700 ohms ±10%, 2 watts	01121	0693-2721	2	1		
R167	Not assigned						
R168	Resistor: variable, composition, 1 megohm ±20%, 1/4 watt	11237	2100-0159	1	1		
R169	Same as R106						
R170	Resistor: variable, composition, 50,000 ohms ±10%	01121	2100-0028	3	1		
R171	Resistor: fixed, composition, 15,000 ohms ±10%, 2 watts	01121	0693-1531	4	1		
R172	Resistor: fixed, composition, 82,000 ohms ±10%, 2 watts	01121	0693-8231	1	1		
R173	Resistor: variable, composition, log taper, 100,000 ohms ±10%	01121	2100-0045	1	1		
R174	Resistor: variable, wirewound, 100,000 ohms ±5%, 8 watts	28480	2100-0120	1	1		
R175	Same as R170						
R176	Same as R119						
R177	Same as R171						
R178	Same as R170						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 8 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
R179, 180, 181	Resistor: fixed, composition, 250 ohms ±1%, 4 watts	28480	620A-26A	4	1		
R182	Resistor: fixed, composition, 18 ohms ±10%, 1 watt	01121	0690-1801	1	1		
R183	Resistor: fixed, composition, 39 ohms ±10%, 1/2 watt	01121	0687-3901	1	1		
R184	Same as R179						
R185	Resistor: variable, composition, linear taper, 1000 ohms ±10%	01121	2100-0024	1	1		
R186	Same as R126; optimum value selected at factory. Average value shown.						
R187	Same as R103						
R188	Same as R142; optimum value selected at factory. Avarage value shown.						
R189	Same as R108						
R190	Same as R142						
R191	Resistor: fixed, composition, 180,000 ohms ±10%, 1 watt	01121	0690-1841	1	1		
R192	Same as R103						
R193	Same as R164						
R194	Same as R103						
R195	Resistor: fixed, composition, 6800 ohms ±10%, 1 watt	01121	0690-6821	1	1		
R196	Same as R135						
R197	Same as R101						
R198	Same as R126						
R199	Same as R124						
R200	Thermistor: disc type	83186	0839-0003	1	0		
R201	Thermistor	83186	0839-0002	1	0		
R202	Thermistor, bead: part of thermistor block	83186	0839-0005	1	0		
R203	Part of RF Attenuator Probe Assy (Misc)						
R204	Resistor: fixed, composition, 100 ohms ±10%, 1/2 watt	01121	0687-1011	1	1		

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 9 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
R205	Same as R124						
R206	Resistor: fixed, composition, 39,000 ohms ±10%, 2 watts	01121	0693-3931	2	1		
R207 thru R302	Not assigned						
R303	Resistor: fixed, composition, 150,000 ohms ±10%, 2 watts	01121	0693-1541	1	1		
R304	Resistor: fixed, composition, 100,000 ohms ±10%, 2 watts	01121	0693-1041	1	1		
R305	Same as R101						
R306	Resistor: fixed, composition, 68,000 ohms ±5%, 1 watt	01121	0689-6835	2	1		
R307	Resistor: variable, composition, linear taper, 20,000 ohms ±20%, 1/3 watt	11237	2100-0161	5	2		
R308	Same as R306						
R309	Resistor: fixed, wirewound, 4500 ohms ±5%, 40 watts	12697	0818-0012	1	1		
R310	Resistor: fixed, wirewound, 5000 ohms ±5%, 12.5 watts	12697	0818-0005	1	1		
R311	Same as R117						
R312	Resistor: fixed, composition, 68,000 ohms ±10%, 1 watt	01121	0690-6831	2	1		
R313	Resistor: fixed, composition, 220,000 ohms ±10%, 1 watt	01121	0690-2241	2	1		
R314	Resistor: fixed, composition, 3.3 megohms ±10%, 1 watt	01121	0690-3351	1	1		
R315	Same as R106						
R316	Resistor: fixed, composition, 100 ohms ±5%, 1 watt	01121	0689-1015	1	1		
R317	Same as R206; optimum value selected at factory. Average value shown.						
R318,319	Same as R135						
R320	Same as R307						
R321 thru R325	Same as R135						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 10 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
R326, 327, 328	Resistor: fixed, composition, 220,000 ohms ±10%, 2 watts	01121	0693-2241	3	1		
R329	Same as R307						
R330	Same as R312; optimum value selected at factory. Average value shown.						
R331	Resistor: fixed, composition, 470 ohms ±10%, 1/2 watt	01121	0687-4711	1	1		
R332	Same as R313						
R333	Same as R106						
R334	Resistor: fixed, composition, 68,000 ohms ±5%, 2 watts	01121	0692-6835	1	1		
R335	Same as R307						
R336	Resistor: fixed, composition, 150,000 ohms ±5%, 2 watts	01121	0692-1545	1	1		
R337	Same as R131						
R338	Same as R307						
R339	Same as R164						
R340	Resistor: fixed, composition, 5600 ohms ±10%, 2 watts	01121	0693-5621	1	1		
R341	Resistor: variable, composition, linear taper, 10,000 ohms ±10%, 1/2 watt	01121	2100-0027	2	1		
R342 thru 345	Resistor: fixed, composition, 3300 ohms ±10%, 2 watts	01121	0693-3321	4	1		
R346,347	Same as R171						
R348	Resistor: fixed, composition, 470 ohms ±10%, 1 watt	01121	0690-4711	1	1		
R349	Resistor: fixed, composition, 33 ohms ±10%, 1 watt	01121	0690-3301	1	1		
R350	Resistor: fixed, composition, 1000 ohms ±10%, 2 watts	01121	0693-1021	1	1		
R351	Part of Power Monitor Probe Assy (Misc)						
R352	Same as R341						
R353	Resistor: fixed, composition, 22 ohms ±10%, 1/2 watt	01121	0687-2201	1	1		
R354	Same as R116; optimum value selected at factory. Average value shown (this resistor may be omitted).						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 11 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
R355,356	Resistor: fixed, composition, 1.2 megohms ±10%, 1/2 watt	01121	0687-1251	2	1		
S1 thru S100	Not assigned						
S101	Switch, rotary: Sync Selector, 5 position	76854	3100-0075	1	1		
S102	Switch, rotary: 8 position	76854	3100-0076	1	1		
S103	Switch, micro: SPDT	91929	3102-0001	1	1		
S104 thru S300	Not assigned						
S301	Switch, toggle: DPDT	04009	3101-0005	1	1		
T1 thru T300	Not assigned						
T301	Transformer, power	28480	9100-0053	1	1		
T302	Transformer, power	28480	9100-0052	1	1		
V1 thru V100	Not assigned						
V101	Tube, electron: 12AT7	80131	1932-0027	2	2		
V102	Tube, electron: 6AL5	80131	1930-0013	3	3		
V103, 104, 105	Tube, electron: 12AU7	80131	1932-0029	7	7		
V106	Same as V102						
V107	Same as V103						
V108	Same as V102						
V109	Same as V103						
V110	Tube, electron: 2D21	80131	1941-0005	1	1		
V111	Same as V103						
V112	Same as V101						
V113	Tube, electron: 5763	80131	1923-0003	1	1		
V114	Tube, klystron	49956	1950-0017	1	1		
V115	Same as V103						
V116 thru V300	Not assigned						
V301	Tube, electron: 5R4GYA	80131	1930-0007	3	3		
V302	Tube, electron: 6AU6	80131	1923-0021	3	3		
V303	Tube, electron: 6AS7G	80131	1932-0018	2	2		
V304	Tube, electron: OA2	80131	1940-0004	5	5		
V305	Same as V301						
V306	Same as V302						
V307	Same as V301						

* See introduction to this section

Table 5-1. Replaceable Parts (Sheet 12 of 13)

Ckt Ref	Description	Mfr *	Stock No.	TQ*	RS*		
V308	Same as V303						
V309	Same as V302						
V310,311	Same as V304						
V312	Tube, electron: OA3	80131	1940-0006	1	1		
V313,314	Same as V304						
	MISCELLANEOUS						
	Center Conductor	28480	620A-36H	1	1		
	Collet	28480	620A-90A	1	1		
	Collet ring	28480	620A-90B	1	1		
	Collet washer	28480	620A-90D	1	1		
	Connector, pin	91737	1250-0017	(1)			
	Dial Assembly: pulse rate	28480	618B-40G	1	0		
	Dial Assembly: pulse delay	28480	618B-40F	1	0		
	Dial Assembly: pulse width	28480	618B-40H	1	0		
	Dial Assembly: vernier	28480	618B-40J	1	0		
	Fuseholder	75915	1400-0084	2	1		
	Filter Assembly, repeller, includes repeller contact	28480	620A-36M	1	1		
	Indicator, light: red	72765	1450-0004	1	0		
	Knob: ZERO SET	28480	G-74F	1	0		
	Knob: FM AMPLITUDE	28480	G-74G	1	0		
	Knob: MOD SELECTOR, SYNC SELECTOR	28480	G-74N	2	0		
	Knob: OUTPUT ATTEN, POWER SET	28480	G-74R	2	0		
	Knob: Frequency Drive	28480	G-74W	1	0		
	Knob: handle (for Frequency Drive)	28480	G-74AE	1	0		
	Mounting Nut	28480	620A-90C	1	1		

*** See introduction to this section**

Table 5-1. Replaceable Parts (Sheet 13 of 13)

Ckt Ref	Description	Mfr *	℗ Stock No.	TQ*	RS*		
	Oil, soluble: for air filter, 1 pint can with spray dispenser	82866	3150-0002				
	RF Attenuator Probe Assembly: includes plunger, terminating resistor (R203), cable and type N connector (J105)	28480	620A-34B	1	1		
	RF Thermistor Block Assembly: includes: 620A-95-28B, thermistors R200 and R201	28480	620A-95-28	1	1		
	RF Thermistor Cup Assembly: includes thermistor R202	28480	620A-95-28A	1	0		
	RF Coaxial Filter for Thermistor Block	28480	620A-95-28B	1	0		
	RF Power Monitor Probe Assembly, includes terminating resistor R351, plunger, and cable	28480	620A-28M	1	1		
	Socket Assembly: includes housing, filters and klystron sockets	28480	618B-52	1	1		
	Socket wrench, klystron removal	28480	618B-38	1	0		
	Waffle washer	28480	618B-88A	1	1		
	Window, dial attenuator	28480	G-99C	1	0		
	Window, frequency dial	28480	620A-40B	1	0		
	Wrench, Allen #8	84396	1470-0008	1	0		

* See introduction to this section

APPENDIX
CODE LIST OF MANUFACTURERS (Sheet 1 of 2)

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

CODE NO.	MANUFACTURER	ADDRESS
00334	Humidial Co.	Colton, Calif.
00335	Westrex Corp.	New York, N.Y.
00373	Garlock Packing Co., Electronic Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00853	Sangamo Electric Co., Cap. Div.	Marion, Ill.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	Pacific Semiconductors, Inc.	Culver City, Calif.
01295	Texas Instruments, Inc. Semiconductor Components Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01561	Chassi-Trak Corp.	Indianapolis, Ind.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Mfg. Co.	Palo Alto, Calif.
02660	Amphenol Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America Semiconductor and Materials Div.	Somerville, N.J.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Products Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp.	El Monte, Calif.
03877	Transitron Electronic Corp.	Wakefield, Mass.
03954	Air Marine Motors, Inc.	Los Angeles, Calif.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04651	Special Tube Operations of Sylvania Electronic Systems	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Filtron Co., Inc. Western Division	Culver City, Calif.
04777	Automatic Electric Sales Corp.	Northlake, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp., Semi-Conductor Dept.	Youngwood, Pa.
05624	Barber Colman Co.	Rockford, Ill.
05783	Stewart Engineering Co.	Soquel, Calif.
06004	The Bassick Co.	Bridgeport, Conn.
06812	Torrington Mfg. Co., West. Div.	Van Nuys, Calif.
07115	Corning Glass Works Electronic Components Dept.	Bradford, Pa.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Semiconductor Corp.	Mountain View, Calif.
07933	Rheem Semiconductor Corp.	Mountain View, Calif.
07980	Boonton Radio Corp.	Boonton, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08718	Cannon Electric Co. Phoenix Div.	Phoenix, Ariz.
08792	CBS Electronics Semiconductor Operations, Div. of C.B.S. Inc.	Lowell, Mass.
09134	Texas Capacitor Co.	Houston, Texas
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11264	Dymec, Inc.	Palo Alto, Calif.
12697	Clarostat Mfg. Co.	Dover, N.H.
14655	Cornell Dubilier Elec. Corp.	So. Plainfield, N.J.
15909	The Daven Co.	Livingston, N.J.
16758	Delco Radio Div. of G. M. Corp.	Kokomo, Ind.
18873	E. I. DuPont and Co., Inc.	Wilmington, Del.
19315	Eclipse Pioneer, Div. of Bendix Aviation Corp.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19701	Electra Manufacturing Co.	Kansas City, Mo.
20183	Electronic Tube Corp.	Philadelphia, Pa.
21520	Fansteel Metallurgical Corp.	No. Chicago, Ill.
21335	The Fafnir Bearing Co.	New Britain, Conn.
21964	Fed. Telephone and Radio Corp.	Clifton, N.J.
24446	General Electric Co.	Schenectady, N.Y.
24455	G. E., Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G. E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
37942	P. R. Mallory & Co., Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C. A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer and Inst. Co.	Philadelphia, Pa.
49956	Raytheon Mfg. Co.	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Sorenson & Co., Inc.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Div. of Daystrom, Inc.	Newark, N.J.
66346	Wollensak Optical Co.	Rochester, N.Y.
70119	Advance Electric and Relay Co.	Burbank, Calif.
70276	Allen Mfg. Co.	Hartford, Conn.
70309	Allied Control Co., Inc.	New York, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc	New York, N.Y.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71218	Bud Radio Inc.	Cleveland, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Allen D. Cardwell Electronic Prod. Corp	Plainville, Conn.
71400	Bussmann Fuse Div. of McGraw-Edison Co.	St. Louis, Mo.
71450	CTS Corp.	Elkhart, Ind.
71468	Cannon Electric Co.	Los Angeles, Calif.
71471	Cinema Engineering Co.	Burbank, Calif.
71482	C. P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71700	The Cornish Wire Co.	New York, N.Y.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A. O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Corp.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast & Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	General Ceramics Corp.	Keasbey, N.J.
72758	Girard-Hopkins	Oakland, Calif.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72982	Erie Resistor Corp.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73138	Helipot Div. of Beckman Instruments, Inc.	Fullerton, Calif.
73293	Hughes Products Div. of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Inc.	Philadelphia, Pa.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	The General Industries Co.	Elyria, Ohio
73905	Jennings Radio Mfg. Co.	San Jose, Calif.
74455	J. H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	Industrial Products Co.	Danbury, Conn.
74970	E. F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75173	Jones, Howard B., Division of Cinch Mfg. Corp.	Chicago, Ill.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Mfg. Co., Inc.	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littelfuse Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C. W. Marwedel	San Francisco, Calif.
76433	Micamold Electronic Mfg. Corp.	Brooklyn, N.Y.

From: F.S.C. Handbook Supplements
H4-1 Dated Oct. 1960
H4-2 Dated Oct. 1960

APPENDIX

CODE LIST OF MANUFACTURERS (Sheet 2 of 2)

CODE NO.	MANUFACTURER	ADDRESS
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Chicago, Ill.
77068	Bendix Corp., Bendix Pacific Div.	No. Hollywood, Calif.
77221	Phaostron Instrument and Electronic Co.	South Pasadena, Calif.
77342	Potter and Brumfield, Inc.	Princeton, Ind.
77630	Radio Condenser Co.	Camden, N.J.
77634	Radio Essentials Inc.	Mt. Vernon, N.Y.
77638	Radio Receptor Co., Inc.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
78283	Signal Indicator Corp.	New York, N.Y.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78790	Transformer Engineers	Pasadena, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80130	Times Facsimile Corp.	New York, N.Y.
80131	Electronic Industries Association Any brand tube meeting EIA standards	Washington, D.C.
80248	Oxford Electric Corp.	Chicago, Ill.
80411	Acro Manufacturing Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80583	Hammerlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments, Inc.	New Haven, Conn.
81415	Wilkor Products, Inc.	Cleveland, Ohio
81453	Raytheon Mfg. Co., Industrial Tube Division	Quincy, Mass.
81483	International Rectifier Corp.	El Segundo, Calif.
81860	Barry Controls, Inc.	Watertown, Mass.
82042	Carter Parts Co.	Skokie, Ill.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Allen B. DuMont Labs., Inc.	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc., Electronic Tube Div.	Emporium, Pa.
82376	Astron Co.	East Newark, N.J.
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Texas Instruments, Inc., Metals and Controls Div., Spencer Products	Attleboro, Mass.
82866	Research Products Corp.	Madison, Wis.
82893	Vector Electronic Co.	Glendale, Calif.
83148	Electro Cords Co.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Union, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83594	Burroughs Corp., Electronic Tube Div.	Plainfield, N.J.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics, Inc.	New York, N.Y.
84396	A. J. Glesener Co., Inc.	San Francisco, Calif.
84411	Good All Electric Mfg. Co.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85474	R. M. Bracamonte & Co.	San Francisco, Calif.
85660	Koiled Kords, Inc.	New Haven, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86684	Radio Corp. of America, RCA Electron Tube Div.	Harrison, N.J.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
89473	General Electric Distributing Corp.	Schenectady, N.Y.
90179	U.S. Rubber Co., Mechanical Goods Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91418	Radio Materials Co.	Chicago, Ill.
91506	Augat Brothers, Inc.	Attleboro, Mass.
91637	Dale Products, Inc.	Columbus, Neb.
91662	Elco Corp.	Philadelphia, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Micro-Switch Div. of Minneapolis Honeywell Regulator Co.	Freeport, Ill.
92196	Universal Metal Products, Inc.	Bassett Puente, Calif.
93332	Sylvania Electric Prod. Inc., Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93983	Insuline-Van Norman Ind., Inc. Electronic Division	Manchester, N.H.
94144	Raytheon Mfg. Co., Receiving Tube Div.	Quincy, Mass.
94145	Raytheon Mfg. Co., Semiconductor Div.	Newton, Mass.
94148	Scientific Radio Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp., Electronics Div.	Carlstadt, N.J.
94310	Tru Ohm Prod. Div. of Model Engineering and Mfg. Co.	Chicago, Ill.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	New York, N.Y.
95265	National Coil Co.	Sheridan, Wyo.
95354	Methode Mfg. Co.	Chicago, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Division of Aerovox	Olean, N.Y.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97539	Automatic and Precision Mfg. Co.	Yonkers, N.Y.
97966	CBS Electronics, Div. of C.B.S., Inc.	Danvers, Mass.
98141	Axel Brothers Inc.	Jamaica, N.Y.
98220	Francis L. Mosley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	New Rochelle, N.Y.
98405	Carad Corp.	Redwood City, Calif.
98734	Palo Alto Engineering Co., Inc.	Palo Alto, Calif.
98925	Clevite Transistor Prod. Div. of Clevite Corp.	Waltham, Mass.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Industries, Electron Products Division	Pasadena, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99821	North Hills Electric Co.	Great Neck, L.I., N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Semiconductor Div. of Hoffman Electronics, Corp.	Evanston, Ill.
99957	Technology Instruments Corp. of Calif.	No. Hollywood, Calif.

THE FOLLOWING H-P VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000C	Connor Spring Mfg. Co.	San Francisco, Calif.
0000D	Connex Corp.	Oakland, Calif.
0000E	Fisher Switches, Inc.	San Francisco, Calif.
0000F	Malco Tool and Die	Los Angeles, Calif.
0000G	Microwave Engineering Co.	Palo Alto, Calif.
0000H	Philco Corp. (Lansdale Division)	Lansdale, Pa.
00001	Telefunken (c/o American Elite)	New York, N.Y.
0000L	Winchester Electronics, Inc.	Santa Monica, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000N	Nahm-Bros. Spring Co.	San Leandro, Calif.
0000P	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
0000R	Metro Cap. Div., Metropolitan Telecommunications Corp.	Brooklyn, N.Y.
0000S	Moulton Electronics	San Carlos, Calif.
0000T	Texas Instruments, Inc. Metals and Controls Div.	Versailles, Ky.

From: F.S.C. Handbook Supplements
H4-1 Dated Oct. 1960
H4-2 Dated Oct. 1960

00015-10
Revised: 23 May 1961

RAYTHEON
KLYSTRON TUBE WARRANTY
FOR TUBES SUPPLIED BY HEWLETT-PACKARD

Raytheon klystron tubes are guaranteed by the manufacturer only to the original purchaser, the Hewlett-Packard Company. For this reason, all warranty claims for premature failure of this tube, if purchased from or supplied by the Hewlett-Packard Company, must be made to Hewlett-Packard and not Raytheon. All credit allowed by Raytheon will be passed on to the customer by Hewlett-Packard.

This klystron tube is guaranteed against defects in manufacture only, for a period of 500 hours filament operation or one year from date of purchase, whichever occurs first. Allowance will be proportional to the percent guaranteed life (filament hours) remaining.

Whenever a tube is returned for a warranty claim, the reverse side of this sheet must be filled out in full and returned with the tube. Follow the shipping instructions carefully to insure safe arrival of the tube. If a tube arrives broken, delay will be caused in determining who is liable -- the transportation company or the shipper. Many tubes will be subjected to a laboratory examination to determine the cause of failure before credit can be allowed. Proper examination is either difficult or impossible when the tube is damaged.

SHIPPING INSTRUCTIONS

1) Fill out the Warranty Claim on the reverse side of this sheet.

2) Carefully wrap the tube in at least 1/4 inch thick cotton batting, or other soft padding material.

3) Wrap the padded tube with the Warranty Claim in heavy kraft paper.

4) Pack in a rigid container which is at least 4 inches larger than the padded tube on all sides. Surround the tube with packed excelsior or similar shock absorbing material.

5) Tubes returned from outside the continental United States should be packed in a wooden box.

6) Mark the box FRAGILE and ship prepaid, preferably via Air Freight or Railway Express. Ship to Hewlett-Packard.

HEWLETT-PACKARD CO. PAGE MILL ROAD, PALO ALTO, CALIF. U.S.A.

RAYTHEON KLYSTRON WARRANTY CLAIM

Please Answer All Questions Fully

FROM: DATE_____

NAME: _____

COMPANY: _____

ADDRESS: _____

_____

Person to contact for further information:

NAME: _____

TITLE: _____

COMPANY: _____

ADDRESS: _____

_____

1) Klystron Type No._____ Serial No._____

2) hp instrument in which tube was used, Model_____, Serial No._____

3) Date tube purchased_____

4) Tube purchased from_____

5) Tube was original_____or replacement_____

6) Total number of hours in operation_____

7) COMPLAINT (Please describe nature of trouble)_____

_____

_____

8) OPERATING CONDITIONS (Please describe conditions prior to and at time of failure)

_____

_____

SIGNATURE_____

_____

WARRANTY

All our products are warranted against defects in materials and workmanship for one year from the date of shipment. Our obligation is limited to repairing or replacing products (except tubes) which prove to be defective during the warranty period. We are not liable for consequential damages.

For assistance of any kind, including help with instruments under warranty, contact your authorized hp Sales Representative for instructions. Give full details of the difficulty and include the instrument model and serial numbers. Service data or shipping instructions will be promptly sent to you. There will be no charge for repair of instruments under warranty, *except transportation charges*. Estimates of charges for non-warranty or other service work will always be supplied, if requested, before work begins.

CLAIM FOR DAMAGE IN SHIPMENT

Your instrument should be inspected and tested as soon as it is received. The instrument is insured for safe delivery. If the instrument is damaged in any way or fails to operate properly, file a claim with the carrier or, if insured separately, with the insurance company.

SHIPPING

On receipt of shipping instructions, forward the instrument prepaid to the destination indicated. You may use the original shipping carton or any strong container. Wrap the instrument in heavy paper or a plastic bag and surround it with three or four inches of shock-absorbing material to cushion it firmly and prevent movement inside the container.

GENERAL

Your authorized hp Sales Representative is ready to assist you in any situation, and you are always welcome to get directly in touch with Hewlett-Packard service departments:

CUSTOMER SERVICE

Hewlett-Packard Company
395 Page Mill Road
Palo Alto, California, U.S.A.
Telephone: (415) 326-1755
TWX No. PAL AL 117-U
Cable: "HEWPACK"

OR (In Western Europe)

Hewlett-Packard S.A.
54-54bis Route Des Acacias
Geneva, Switzerland
Telephone: (022) 42. 81. 50
Cable: "HEWPACKSA"

RETURN TO
ENGR. STOCKROOM
FRENCH ROAD

RETURN TO
ENGR. STOCKROOM
FRENCH ROAD

RETURN TO
ENGR. STOCKROOM
FRENCH ROAD

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